Therapeutic Class Overview
Oral Anticoagulants

Therapeutic Class

- **Overview/Summary:** The oral anticoagulants, dabigatran etexilate mesylate (Pradaxa®), rivaroxaban (Xarelto®), and warfarin (Coumadin®, Jantoven®), each have a unique mechanism of action and are Food and Drug Administration (FDA)-approved for various cardiovascaular indications. Specifically, rivaroxaban and warfarin are approved for use as thromboprophylaxis, and all three agents can be used to manage thromboembolic complications associated with atrial fibrillation. Warfarin is also approved to reduce the risk of death, recurrent myocardial infarction, and thromboembolic events after myocardial infarction. The specific FDA-approved indications of the oral anticoagulants are outlined in Table 1.[1-3] Warfarin, a vitamin K antagonist, has been the principle oral anticoagulant for more than 60 years and has extensive, well established data demonstrating its safety and efficacy in all FDA-approved indications.[3,4] Dabigatran etexilate mesylate, a direct thrombin inhibitor, and rivaroxaban, a factor Xa inhibitor, are both novel oral anticoagulants approved in 2010 and 2011.[1,2] While the data for dabigatran etexilate mesylate and rivaroxaban are not as substantial as compared to warfarin, the newer oral anticoagulants are associated with several advantages. Unlike warfarin, dabigatran etexilate mesylate and rivaroxaban are not associated with a narrow therapeutic window, numerous drug-drug and -food interactions, or monitoring requirements. However, it has been stated that due to the lack of surrogate markers to measure the efficacy of anticoagulation with the new oral anticoagulants, clinicians may find it difficult to find an objective way to assess a patient's adherence to therapy, and whether a fixed-dose regimen can be universally applied to all patients.[1-5] Dabigatran etexilate mesylate is available for twice-daily dosing compared to once-daily with rivaroxaban and warfarin.[1-3] Currently, warfarin is the only oral anticoagulant that is available generically.

Table 1. Current Medications Available in Therapeutic Class[1-3]

Generic (Trade Name)	Food and Drug Administration Approved Indications	Dosage Form/Strength	Generic Availability
Dabigatran etexilate mesylate (Pradaxa®)	Reduce the risk of stroke and systemic embolism in patients with non-valvular atrial fibrillation	Capsule: 75 mg 150 mg	-
Rivaroxaban (Xarelto®)	Prophylaxis of deep vein thrombosis, which may lead to pulmonary embolism in patients undergoing knee or hip replacement surgery, reduce the risk of stroke and systemic embolism in patients with non-valvular atrial fibrillation*	Tablet: 10 mg 15 mg 20 mg	-
Warfarin (Coumadin®†, Jantoven®†)	Prophylaxis and treatment of the thromboembolic complications associated with atrial fibrillation and/or cardiac valve replacement; prophylaxis and treatment of venous thrombosis and its extension, pulmonary embolism; reduce the risk of death, recurrent myocardial infarction, and thromboembolic events such as stroke or systemic embolization after myocardial infarction	Tablet: 1 mg 2 mg 2.5 mg 3 mg 4 mg 5 mg 6 mg 7.5 mg 10 mg	✔

*There is limited data on the relative effectiveness of rivaroxaban and warfarin in reducing the risk of stroke and systemic embolism when warfarin therapy is well controlled.
†Generic available in at least one dosage form and/or strength.

Evidence-based Medicine

- As it has been the principle oral anticoagulant for more than 60 years, the clinical evidence derived from meta-analyses and Cochrane Reviews demonstrating the safety and efficacy of warfarin in Food and Drug Administration-approved indications is well established.[3,6-15]

Therapeutic Class Review
Oral Anticoagulants

Overview/Summary

The oral anticoagulants, dabigatran etexilate mesylate (Pradaxa®), rivaroxaban (Xarelto®), and warfarin (Coumadin®, Jantoven®) each have a unique mechanism of action and are Food and Drug Administration (FDA)-approved for the various cardiovascular indications outlined in Table 2.[1-3] Warfarin, has been the principle oral anticoagulant for more than 60 years and has extensive, well established data demonstrating its safety and efficacy in all of its FDA-approved indications.[4-6] Dabigatran etexilate mesylate, a direct thrombin inhibitor (DTI) and rivaroxaban, a selective factor Xa inhibitor, are novel oral anticoagulants that are approved to reduce the risk of stroke and systemic embolism in patients with non-valvular atrial fibrillation (AF).[1,2] Rivaroxaban, is also indicated for the prophylaxis of deep vein thrombosis (DVT), which may lead to pulmonary embolism (PE) in patients undergoing knee or hip replacement surgery.[2]

Warfarin is a vitamin K antagonist (VKA) that works by interfering with the synthesis of vitamin K dependent clotting factors and anticoagulant proteins C and S. Specifically, warfarin inhibits the vitamin K epoxide reductase enzyme complex, resulting in the blockade of the regeneration of vitamin K_1 epoxide.[3-6] Dabigatran etexilate mesylate is a prodrug that is converted to dabigatran, a potent, competitive inhibitor of thrombin. As a DTI, dabigatran inhibits the conversion of fibrinogen into fibrin; therefore, inhibiting the development of a thrombus. Both free and fibrin-bound thrombin, and thrombin-induced platelet aggregation are inhibited by dabigatran etexilate mesylate.[1,5,6] Rivaroxaban directly inhibits factor Xa, thereby preventing the generation of thrombin and ultimately preventing platelet activation and the formation of fibrin clots.[2,5,6] Warfarin is available generically while dabigatran etexilate mesylate and rivaroxaban are branded oral anticoagulants.[3,5,6]

The evidence demonstrating the efficacy of warfarin for FDA-approved indications, including reducing the risk of stroke and systemic embolism in patients with AF, is well established, and currently warfarin is considered the standard of care in high-risk patients with AF.[7-9] However, therapy with warfarin is associated with several challenges including a slow onset and offset of action, significant and unpredictable inter-individual variability in pharmacologic response, a narrow therapeutic window necessitating frequent monitoring, and numerous food and drug interactions. In addition, maintenance of a therapeutic level of anticoagulation may be difficult for some patients and requires a good understanding of the pharmacokinetic and pharmacodynamic properties of warfarin.[4,10] In comparison to warfarin, treatment with dabigatran etexilate mesylate or rivaroxaban does not require monitoring, but it has been stated that because of this, clinicians may discover it difficult to find an objective way to assess a patient's adherence to therapy, and whether a fixed-dose regimen can be universally applied to all patients. Dabigatran etexilate mesylate requires twice-daily dosing compared to rivaroxaban and warfarin which are administered once-daily.[1-3] Warfarin does not require a dosage adjustment in patients with renal impairment, while a lower dose of dabigatran etexilate mesylate and rivaroxaban (AF only) is recommended.[1-3] In situations where a major bleed occurs, unlike warfarin, no specific antidote is available for the new oral anticoagulants.[10] The bleeding risk appears to be comparable overall between dabigatran etexilate mesylate and warfarin; however, in clinical trials warfarin was associated with more intracranial bleeding, while dabigatran etexilate mesylate was associated with more gastrointestinal bleeding.[1,11] Also of note, in the clinical trial that was the basis for FDA-approval of dabigatran etexilate mesylate, the incidence of myocardial infarction (MI) was higher with dabigatran etexilate mesylate compared to warfarin.[11] Whether or not this is a true risk associated with the agent is unclear; however, further evaluation of the safety and efficacy of dabigatran etexilate mesylate in acute coronary syndrome is currently ongoing.[10] In the trial that was the basis for FDA-approval of rivaroxaban for use in AF, there was no difference in major and clinically relevant nonmajor bleeding between rivaroxaban and warfarin, but like dabigatran etexilate mesylate, rivaroxaban was associated with a lower risk of intracranial bleeding and a higher incidence of gastrointestinal bleeding compared to warfarin. There was no increase in the risk of MI associated with rivaroxaban in this trial.[12] In clinical trials for DVT prophylaxis, rivaroxaban demonstrated a comparable bleeding profile to enoxaparin, a low molecular weight heparin (LMWH)

agent; both treatments were associated with similar rates of major bleeding and hemorrhagic wound complications.[13-16]

The current clinical guidelines support the use of the oral anticoagulants for their FDA-approved indications.[8,9,17-19] Due to the relatively recent approval of dabigatran etexilate mesylate and rivaroxaban for their respective indications, there is little guidance from clinical guidelines as to role of these new oral anticoagulants. Standard anticoagulation therapy in patients with AF consists of VKAs, such as warfarin, and aspirin.[8-10] Use of either agent is dependent on patient specific risk factors and past medical history. Patients with AF who have had a prior ischemic stroke, transient ischemic attack or systemic embolism; or who have two or more risk factors (>75 years of age, history of hypertension, diabetes, moderately or severely impaired left ventricular systolic function and/or heart failure), should receive long-term anticoagulation therapy with warfarin because of the high risk of future ischemic stroke in these patients. Patients with AF who have one risk factor should receive either warfarin or aspirin; however, patients at intermediate risk of ischemic stroke should receive warfarin over aspirin. Patients ≤75 years of age with AF and no other risk factor should be placed on long-term aspirin therapy.[8,9,17] In 2011, the American College of Cardiology Foundation published a focused update on the management of AF, stating that dabigatran etexilate mesylate is useful as an alternative to warfarin, and patients already receiving warfarin with excellent International Normalized Ratio (INR) control may have little to gain by switching to dabigatran etexilate mesylate. Furthermore, selection of patients with AF who could benefit from dabigatran etexilate mesylate over warfarin should consider individual clinical features including the ability to comply with twice-daily dosing, availability of an anticoagulation management program to sustain routine INR monitoring, patient preferences, cost and other factors.[18] To date, the organization has not released any guidance the role of rivaroxaban in this patient population.

According to the American College of Chest Physicians, the routine use of a LMWH agent, fondaparinux, or a VKA is recommended for the prevention of venous thromboembolism (VTE) in patients undergoing an orthopedic surgery, with only a LMWH agent recommended in high-risk patients who are undergoing knee arthroscopy specifically. Thromboprophylaxis with one of these agents in patients undergoing orthopedic surgery should be continued for at least ten days, or 35 days if the patient is undergoing total hip and knee replacement surgery, as well as hip fracture surgery. For the prevention of VTE in acutely ill medical patients, LMWH agents, low-dose unfractionated heparin (UFH), or fondaparinux are recommended, while only the LMWH agents and VKAs are recommended in patients with cancer. The current guidelines for the prevention of VTE from the American College of Chest Physicians has not been updated to reflect the role of rivaroxaban in patients undergoing hip and knee replacement surgeries.[17] However, the 2010 National Institute for Health and Clinical Excellence and Scottish Intercollegiate Guidelines Network guidelines both recommend rivaroxaban, along with traditional antithrombotics, for thromboprophylaxis in these surgeries.[20,21]

For the treatment of an acute DVT, anticoagulation should be initiated with a LMWH agent, UFH or fondaparinux. Therapy with these agents typically lasts for at least five days, until the INR is at least 2.0 or greater for 24 hours, and it is recommended that a VKA, together with one of these agents, be initiated on the first day of treatment. Anticoagulation therapy with a VKA typically lasts for a period of three months in these patients; however, extended therapy may be required. Because patients with cancer are at high risk, it is recommended that initial treatment of an acute DVT with a LMWH agent continue for the first three to six months in these patients, followed by indefinite therapy with either a VKA or LMWH agent. Recommendations for the treatment of an acute PE are the same as those for an acute DVT.[17]

For secondary prevention in post-MI patients, the American College of Cardiology recommends the use of warfarin in aspirin-allergic patients who have an indication for anticoagulation. Depending on whether a patient is allergic to aspirin or a stent is implanted, warfarin may also be appropriate as combination therapy with aspirin or clopidogrel in post-MI patients. The American College of Cardiology recommends that post-MI patients with persistent or paroxysmal AF receive warfarin, and therapy with warfarin is recommended if evidence of a thrombus is present following an MI. For this indication, warfarin therapy may last at least three months or indefinitely, depending on the patient's risk of bleeding. Despite these recommendations, the role of long-term warfarin therapy in post-MI patients remains controversial, and

aspirin remains the preferred antithrombotic.[19,22] The American College of Chest Physicians also provides recommendations for the use of warfarin in this indication; however, they are of lower quality. The recommendations from the American College of Chest Physicians further support that the evidence surrounding the use of warfarin in post-MI patients is evolving.[17]

Medications

Table 1. Medications Included Within Class Review

Generic Name (Trade Name)	Medication Class	Generic Availability
Dabigatran etexilate mesylate (Pradaxa®)	Oral anticoagulants	-
Rivaroxaban (Xarelto®)	Oral anticoagulants	-
Warfarin (Coumadin®*, Jantoven®*)	Oral anticoagulants	✔

*Generic available in at least one dosage form or strength.

Indications

Table 2. Food and Drug Administration (FDA)-Approved Indications[1-3,5,6]

Indication	Dabigatran Etexilate Mesylate	Rivaroxaban	Warfarin
Prophylaxis and treatment of the thromboembolic complications associated with atrial fibrillation and/or cardiac valve replacement			✔
Prophylaxis and treatment of venous thrombosis and its extension, pulmonary embolism			✔
Reduce the risk of death, recurrent myocardial infarction, and thromboembolic events such as stroke or systemic embolization after myocardial infarction			✔
Reduce the risk of stroke and systemic embolism in patients with non-valvular atrial fibrillation	✔	✔*	
Prophylaxis of deep vein thrombosis, which may lead to pulmonary embolism in patients undergoing knee or hip replacement surgery		✔	

*There is limited data on the relative effectiveness of rivaroxaban and warfarin in reducing the risk of stroke and systemic embolism when warfarin therapy is well controlled.

Dabigatran etexilate mesylate has also been evaluated for the prevention of venous thromboembolism (VTE) but currently does not have Food and Drug Administration approval for this indication.[10] Rivaroxaban is currently being evaluated for the treatment of VTE and acute coronary syndromes.[24]

Pharmacokinetics

Table 3. Pharmacokinetics[1-3,5,6]

Generic Name	Bioavailability (%)	Renal Excretion (%)	Active Metabolites	Serum Half-Life (hours)
Dabigatran etexilate mesylate	3 to 7	80*	Dabigatran (major); 1-, 2-, 3-, 4-O-acylglucuronide (all minor)	12 to 17
Rivaroxaban	80 to 100	66	None	5 to 9
Warfarin	≈100	92	Warfarin alcohols	168

*Intravenous administration.

Clinical Trials

As it has been the principle oral anticoagulant for more than 60 years, the evidence demonstrating the safety and efficacy of warfarin in Food and Drug Administration (FDA)-approved indications is well

established. Because of this, only meta-analyses and Cochrane Reviews evaluating warfarin are included in Table 4.[25-34]

Approval of dabigatran etexilate mesylate for use in atrial fibrillation (AF) was based on the clinical evidence for safety and efficacy derived from the Randomized Evaluation of Long-Term Anticoagulation Therapy (RE-LY) trial (N=18,113). The RE-LY trial was a noninferiority, multicenter, randomized, parallel-group trial comparing two blinded doses of dabigatran etexilate mesylate (110 and 150 mg twice-daily) with open-label warfarin in patients with non-valvular, persistent, paroxysmal, or permanent AF. Patients enrolled in the RE-LY trial also had at least one of the following risk factors: previous stroke, transient ischemic attack or systemic embolism; left ventricular ejection fraction <40%; symptomatic heart failure, New York Heart Association Class ≥2; age >75 years or age ≥65 years plus diabetes, coronary artery disease, or hypertension. For the primary composite endpoint, occurrence of stroke and systemic embolism, both doses of dabigatran etexilate mesylate demonstrated noninferiority to warfarin (P<0.001). Specifically, the primary endpoint occurred at a rate of 1.53% per year (relative risk [RR], 0.91; 95% confidence interval [CI], 0.74 to 1.11; P=0.34) and 1.10% per year (RR, 0.66; 95% CI, 0.53 to 0.82; P<0.001) for dabigatran etexilate mesylate 110 and 150 mg compared to 1.69% per year with warfarin. The 150 mg dose of dabigatran etexilate mesylate achieved "superiority" over warfarin; however, the 110 mg dose did not. The treatment effect observed with dabigatran etexilate mesylate was primarily a reduction in the incidence of stroke. The rate of major bleeding (life-threatening, non life-threatening, and gastrointestinal bleeding) was also reduced with dabigatran etexilate mesylate compared to warfarin (dabigatran etexilate mesylate 110 mg: RR, 0.80; 95% CI, 0.69 to 0.93; P=0.003; dabigatran etexilate mesylate 150 mg: RR, 0.93; 95% CI, 0.81 to 1.07; P=0.31). For the secondary endpoints evaluated, no significant differences were observed between dabigatran etexilate mesylate and warfarin in regard to the rate of death from any cause and pulmonary embolism. However, the rate of myocardial infarction was higher (P=0.048 with dabigatran etexilate mesylate 150 mg vs warfarin) and the rate of hospitalization was lower (P=0.003 with dabigatran etexilate mesylate 110 mg vs warfarin) with dabigatran etexilate mesylate.[11] Several subgroup analyses of the RE-LY trial have been published.[35-37] In one analysis, it was revealed that previous exposure to a vitamin K antagonist does not influence the benefits of dabigatran etexilate mesylate compared to warfarin.[35] Another revealed that the effects of dabigatran etexilate mesylate in patients with a previous stroke or transient ischemic attack are consistent with those of other patients in the RE-LY trial.[36]

In terms of the evidence demonstrating the efficacy of dabigatran etexilate mesylate for the prevention of stroke and systemic embolization in patients with non-valvular AF, a phase II, randomized-controlled trial was conducted to determine whether a dose-related incidence of bleeding was to be expected with the administration of the agent, and to determine what doses should be used in future clinical trials for further evaluation. This 12 week trial established a dose response for bleeding and an upper limit of tolerability (300 mg twice-daily plus aspirin) for dabigatran etexilate mesylate based on the frequency of major and clinically significant bleeding events.[38] Please note, the FDA-approved dosing for dabigatran etexilate mesylate, in patients with adequate renal function, is 150 mg twice-daily.[1]

Approval of rivaroxaban for use in AF was based on results from the Rivaroxaban Once Daily Oral Direct Factor Xa Inhibition Compared to Vitamin K Antagonism for Prevention of Stroke and Embolism Trial in Atrial Fibrillation (ROCKET AF) in which 14,264 patients with non-valvular AF who were considered to be at increased risk for stroke were enrolled. Patients received rivaroxaban 20 mg once-daily (or 15 mg once-daily in patients with renal impairment) or dose-adjusted warfarin (to target an International Normalized Ratio [INR] of 2.0 to 3.0). The primary endpoint, a composite of stroke or systemic embolism in the per-protocol population, occurred in 188 patients (1.7% per year) with rivaroxaban and 241 patients (2.2% per year) with warfarin (hazard ration [HR], 0.79; 95% CI, 0.66 to 0.96; P<0.001 for noninferiority). The results from the intention-to-treat population did not achieve "superiority" (P=0.12).[12] Package labeling for rivaroxaban acknowledges the low percentage of "time in INR range" for patients randomized to warfarin as compared to other clinical trials, and states that is it unknown how rivaroxaban compares to warfarin when patients are well controlled on warfarin.[2] However, there was no difference in the rate of major and clinically relevant nonmajor bleeding between rivaroxaban and warfarin (14.9 and 14.5% per year, respectively; HR, 1.03; 95% CI, 0.96 to 1.11; P=0.44). Rates of intracranial hemorrhage were

significantly lower with rivaroxaban (0.5 vs 0.7% per year; HR, 0.67; 95% CI, 0.47 to 0.93; *P*=0.02); however, the rate of major bleeding from a gastrointestinal site was significantly higher with rivaroxaban (3.2 vs 2.2%; *P*<0.001) compared to warfarin.[12]

Approval of rivaroxaban for prophylaxis of deep vein thrombosis (DVT) was based on the evidence derived from a global program of clinical trials known collectively as Regulation in Orthopedic Surgery to Prevent Deep Vein thrombosis and Pulmonary Embolism (RECORD). The RECORD program consists of four individual trials (RECORD1, 2, 3 and 4) evaluating the safety and efficacy of rivaroxaban for thromboprophylaxis in patients undergoing total elective hip and knee replacement surgeries. Primary and secondary endpoints were similar among the four trials and major bleeding was defined as bleeding that was fatal, involved a critical organ or required reoperation, clinically overt bleeding outside the surgical site that was associated with a decrease in the hemoglobin level of at least 2 g/dL, or a bleed requiring an infusion of two units or more of blood.[13-16]

RECORD1 (N=4,541) and RECORD2 (N=2,509) were two, large, double-blind, multicenter, randomized-controlled trials evaluating rivaroxaban for thromboprophylaxis in patients undergoing hip replacement surgery. Both trials compared rivaroxaban 10 mg once-daily to enoxaparin 40 mg once-daily. In RECORD1 rivaroxaban and enoxaparin were both administered for 35 days, while in RECORD2 rivaroxaban was administered for 31 to 39 days (extended thromboprophylaxis) and enoxaparin for 10 to 14 days.[13,14] In RECORD1, the risk of the primary composite endpoint of any DVT, nonfatal pulmonary embolism, or death from any cause up to 36 days was significantly reduced with rivaroxaban compared to enoxaparin (1.1 vs 3.7%; absolute risk reduction [ARR], -2.6%; 95% CI, -3.7 to -1.5; *P*<0.001). Treatment with rivaroxaban also significantly reduced the risk of major venous thromboembolism (VTE) (0.2 vs 2.0%; ARR, -1.7%; 95% CI, -2.5 to -1.0; *P*<0.001).[13] Rivaroxaban had no beneficial effect on all-cause mortality (on-treatment: 0.3 vs 0.3%; *P*=1.00, follow-up: 0.1 vs 0.0%; *P*=1.00). The rate of major bleeding was similar between rivaroxaban and enoxaparin (0.3 vs 0.1%; *P*=0.18). In addition, rivaroxaban and enoxaparin had similar rates of any on-treatment bleeding (6.0 vs 5.9%; *P*=0.94) and hemorrhagic wound complications (1.5 vs 1.7%; *P* value were not reported).[13] In RECORD2, rivaroxaban significantly reduced the risk of the primary composite endpoint up to 30 to 42 days (2.0 vs 9.3%; ARR, 7.3%; 95% CI, 5.2 to 9.4; *P*<0.0001). In this trial, the risk of major VTE was also significantly reduced with rivaroxaban (0.6 vs 5.1%; ARR, 4.5%; 95% CI, 3.0 to 6.0; *P*<0.0001). Rivaroxaban again demonstrated no beneficial effects on all-cause mortality (0.2 vs 0.7%; *P*=0.29). Similar to RECORD1, there were no differences between rivaroxaban and enoxaparin in the rates of major bleeding, any on-treatment nonmajor bleeding, and hemorrhagic wound complications (*P* values not reported).[14]

Rivaroxaban for thromboprophylaxis in patients undergoing knee replacement surgery was evaluated in RECORD3 (N=2,531) and RECORD4 (N=3,148). Similar to RECORD1 and RECORD2, these were large, double-blind, double-dummy, multicenter, randomized-controlled trials. The trials compared rivaroxaban 10 mg once-daily to either enoxaparin 40 mg once-daily (RECORD3) or 30 mg twice-daily (RECORD4) for 10 to 14 days. Again, all primary and secondary endpoints were similar to RECORD1 and RECORD2. Furthermore, results from all four trials were consistent.[15,16] In RECORD3, rivaroxaban significantly reduced the risk of the primary composite endpoint compared to enoxaparin up to 17 days (9.6 vs 18.9%; absolute risk difference [ARD], -9.2%; 95% CI, -12.4 to -5.9; *P*<0.001). Rivaroxaban also significantly reduced the rate of major VTE (1.0 vs 2.6%; ARD, -1.6%; 95% CI, -2.8 to -0.4; *P*=0.01) and was not associated with any mortality benefit (*P*=0.21). The rates of major bleeding (*P*=0.77) and any on-treatment bleeding (*P*=0.93) were similar between rivaroxaban and enoxaparin, as well as the rate of hemorrhagic wound complications (*P* value not reported).[15] RECORD4 demonstrated similar results, except in this trial, there was no difference between rivaroxaban and enoxaparin in the rate of major VTE (*P*=0.1237).[16]

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Table 4. Clinical Trials

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
Reducing the Risk of Stroke and Systemic Embolism in Patients with Non-valvular Atrial Fibrillation				
Connolly et al[11] RE-LY Dabigatran 110 mg BID vs dabigatran 150 mg BID vs warfarin 1, 3, or 5 mg; dose adjusted to maintain an INR of 2.0 to 3.0 (OL)	DB, MC, RCT Patients with AF documented on electro-cardiography performed at screening or within 6 months beforehand and ≥1 of the following: previous stroke or TIA, a left ventricular ejection fraction <40%, NYHA ≥II heart failure symptoms within 6 months before screening and ≥75 years of age or 65 to 74 years of age plus diabetes, hypertension or CAD	N=18,113 2 years	Primary: Composite of stroke or systemic embolism, major hemorrhage Secondary: Death, MI, PE, TIA, hospitalization	Primary: Both doses of dabigatran were noninferior to warfarin (*P*<0.001). Stroke or systemic embolism occurred in 182 dabigatran 110 mg- (1.53% per year), 134 dabigatran 150 mg- (1.1% per year) and 199 warfarin-treated patients (1.69% per year). The 150 mg dose of dabigatran was "superior" to warfarin (RR, 0.66; 95% CI, 0.53 to 0.82; *P*<0.001), but the 110 mg dose was not (RR, 0.91; 95% CI, 0.74 to 1.11; *P*=0.34). Rates of hemorrhagic stroke were 0.38, 0.12 (RR, 0.31; 95% CI, 0.17 to 0.56; *P*<0.001) and 0.10% (RR, 0.26; 95% CI, 0.14 to 0.49; *P*<0.001) per year in warfarin-, dabigatran 110 mg- and dabigatran 150 mg-treated patients. The rate of major bleeding (life-threatening, non life-threatening and gastrointestinal) was 3.36, 2.71 (RR, 0.80; 95% CI, 0.69 to 0.93; *P*=0.003) and 3.11% (RR, 0.93; 95% CI, 0.81 to 1.07; *P*=0.31) per year in warfarin-, dabigatran 110 mg- and dabigatran 150 mg-treated patients. Rates of life-threatening bleeding, intracranial bleeding and major or minor bleeding were higher in warfarin-treated patients (1.80, 0.74 and 18.15%, respectively) compared to either dabigatran 110 (1.22, 0.23 and 14.62%, respectively) or 150 mg-treated patients (1.45, 0.30 and 16.42%, respectively) (*P*<0.05 for all comparisons of dabigatran and warfarin). There was a significantly higher rate of major gastrointestinal bleeding in dabigatran 150 mg-treated patients compared to warfarin-treated patients (*P*=0.43 for dabigatran 110 mg vs warfarin and *P*<0.001 for dabigatran 150 mg vs warfarin). The net clinical benefit outcome consisted of major vascular events, major bleeding and death. The rates of this combined outcome were 7.64, 7.09 (RR, 0.92; 95% CI, 0.84 to 1.02; *P*=0.10) and 6.91% (RR, 0.91; 95% CI, 0.82 to 1.00; *P*=0.04) per year in warfarin, dabigatran 110 mg- and dabigatran 150 mg-treated patients. Secondary: Rates of death from any cause were 4.13, 3.75 (RR, 0.91; 95% CI, 0.80 to

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				1.03; *P*=0.13) and 3.64% (RR, 0.88; 95% CI, 0.77 to 1.00; *P*=0.051) per year in warfarin-, dabigatran 110 mg- and dabigatran 150 mg-treated patients. The rate of MI was 0.53, 0.72 (RR, 1.35; 95% CI, 0.98 to 1.87; *P*=0.07) and 0.74% (RR, 1.38; 95%, 1.00 to 1.91; *P*=0.048) per year in warfarin-, dabigatran 110 mg- and dabigatran 150 mg-treated patients. The rate of PE was 0.09, 0.12 (RR, 1.26; 95% CI, 0.57 to 2.78; *P*=0.56) and 0.15% (RR, 1.61; 95% CI, 0.76 to 3.42; *P*=0.21) per year in warfarin-, dabigatran 110 mg- and dabigatran 150 mg-treated patients. Data regarding the incidences of TIA were not reported. The rate of hospitalization was 20.8, 19.4 (RR, 0.92; 95% CI, 0.87 to 0.97; *P*=0.003) and 20.2% (RR, 0.97; 95% CI, 0.92 to 1.03; *P*=0.34) per year in warfarin-, dabigatran 110 mg- and dabigatran 150 mg-treated patients.
Ezekowitz et al[35] Dabigatran 110 mg BID vs dabigatran 150 mg BID vs warfarin 1, 3, or 5 mg; dose adjusted to maintain an INR of 2.0 to 3.0 (OL)	Subanalysis of the RE-LY trial[11] Patients enrolled in the RE-LY trial who were naïve to and experienced with VKAs	N=18,113 2 years	Primary: Composite of stroke or systemic embolism, major hemorrhage Secondary: Death, MI, PE, TIA, hospitalization	Primary: Approximately half of the patients were VKA-naïve (50.4%). Combined stroke and systemic embolism rates were similar in dabigatran 110 mg-treated patients for both the VKA-naïve and -experienced cohorts compared to warfarin-treated patients (RR, 0.93; 95% CI, 0.70 to 1.25; *P*=0.65 and RR, 0.87; 95% CI, 0.66 to 1.15; *P*=0.32). In dabigatran 150 mg-treated patients, both VKA-naïve (RR, 0.63; 95% CI, 0.46 to 0.87; *P*=0.005) and -experienced cohorts (RR, 0.66; 95% CI, 0.49 to 0.89; *P*=0.007) had significantly lower risk of stroke or systemic embolism compared to warfarin-treated patients. Major bleeding rates were lower in the VKA-experienced cohort in dabigatran 110 mg-treated patients compared to warfarin-treated patients (RR, 0.74; 95% CI, 0.60 to 0.90; *P*=0.003). The VKA-naïve cohort in dabigatran 110 mg-treated patients (RR, 0.87; 95% CI, 0.72 to 1.07; *P*=0.19) and the VKA-naïve (RR, 0.94; 95% CI, 0.77 to 1.15; *P*=0.55) and –experienced cohort (RR, 0.92; 95% CI, 0.76 to 1.12; *P*=0.41) in dabigatran 150 mg-treated patients were similar compared to warfarin-treated patients. Intracranial bleeding events were lower in dabigatran 110 VKA-naïve and -

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				experienced cohorts (RR, 0.27; 95% CI, 0.14 to 0.52; *P*<0.001; RR, 0.32; 95% CI, 0.18 to 0.56; *P*<0.001) and in dabigatran 150 mg VKA-naïve and -experienced cohorts (RR, 0.46; 95% CI, 0.27 to 0.78; *P*=0.005; RR, 0.40; 95% CI, 0.24 to 0.67; *P*<0.001) compared to warfarin-treated patients. Secondary: Rates of life threatening bleeding, disabling stroke and death (when combined) were significantly lower in the VKA-experienced patients in both dabigatran 110 mg- (RR, 0.82; 95% CI, 0.70 to 0.96; *P*=0.01) and 150 mg-treated cohort (RR, 0.80; 95% CI, 0.68 to 0.93; *P*=0.004) compared to warfarin-treated patients, but similar for the VKA-naïve cohort. When comparing this combined outcome in VKA-naïve and -experienced cohorts within treatments, the rate was lower in VKA-experienced cohort than in the -naïve cohort (RR, 0.83; 95% CI, 0.71 to 0.98; *P*=0.03), as was the cardiovascular death rate (RR, 0.73; 95% CI, 0.58 to 0.92; *P*=0.007). In dabigatran 150 mg-treated patients, the rate of this combined outcome trended lower in VKA-experienced cohort. There were no differences in the rates of MI among the treatments. Gastrointestinal bleeding rates were similar for dabigatran 110 mg- and warfarin-treated patients, but significantly higher in both dabigatran 150 mg VKA-naïve (RR, 1.56; 95% CI, 1.15 to 2.10; *P*=0.004) and -experienced cohorts (RR, 1.42; 95% CI, 1.06 to 1.89; *P*=0.02) compared to warfarin-treated patients.
Diener et al (abstract)[36] Dabigatran 110 mg BID vs dabigatran 150 mg BID vs warfarin 1, 3, or 5 mg;	Subanalysis of the RE-LY trial[11] Patients enrolled in the RE-LY trial who had a previous stroke or TIA	N=18,113 2 years	Primary: Composite of stroke or systemic embolism, major hemorrhage Secondary: Death, MI, PE, TIA, hospitalization	Primary: Within the subgroup of patients with previous stroke or TIA, 1,195, 1,233 and 1,195 patients were from the dabigatran 110 mg, dabigatran 150 mg and warfarin groups. Stroke or systemic embolism occurred in 65 warfarin-treated patients (2.78% per year) compared to 55 (2.32% per year) dabigatran 110 mg- (RR, 0.84; 95% CI, 0.58 to 1.20) and 51 (2.07% per year) dabigatran 150 mg-treated patients (RR, 0.75; 95% CI, 0.52 to 1.08). The rate of major bleeding was significantly lower in dabigatran 110 mg-treated patients (RR, 0.66; 95% CI, 0.48 to 0.90), and similar in dabigatran 150 mg-treated patients (RR, 1.01; 95% CI, 0.77 to 1.34) compared to

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
dose adjusted to maintain an INR of 2.0 to 3.0 (OL)				warfarin-treated patients. Secondary: The effects of both doses of dabigatran compared to warfarin were not different between patients with previous stroke or TIA and those without for any of the outcomes from RE-LY apart from vascular death (dabigatran 110 mg vs warfarin; *P*=0.038).
Wallentin et al[37] Dabigatran 110 mg BID vs dabigatran 150 mg BID vs warfarin 1, 3, or 5 mg; dose adjusted to maintain an INR of 2.0 to 3.0 (OL) The cTTR was estimated by averaging the TTR for individual warfarin-treated patients.	Subanalysis of the RE-LY trial[11] Patients enrolled in the RE-LY trial across the 3 treatment groups within 4 groups defined by quartiles of cTTR (<57.1, 57.1 to 65.5, 65.5 to 72.6 and >72.6%)	N=18,113 2 years	Primary: Composite of stroke or systemic embolism, major hemorrhage Secondary: Death, MI, PE, TIA, hospitalization	Primary: In the total population, the rate of the primary outcome of stroke and systemic embolism was reduced from 1.71% per year in warfarin-treated patients, to 1.54% per year in dabigatran 110 mg-treated patients (noninferiority; *P*<0.001) and to 11.1% per year in dabigatran 150 mg-treated patients ("superiority"; *P*<0.001). Event rates seemed to decrease with higher cTTR in warfarin-treated patients; however, there were no significant interactions between cTTR and stroke and systemic embolism in dabigatran- vs warfarin-treated patients. The rate of nonhemorrhagic stroke and systemic embolism seemed to be lower with higher cTTR in warfarin-treated patients (*P*=0.08). In the total population, the rate of major bleeding was 3.57% per year in warfarin-treated patients compared to 2.87 ("superiority"; *P*=0.003) and 3.32% ("superiority"; *P*=0.31) per year in dabigatran 110 mg- and dabigatran 150 mg-treated patients. The rate of major bleeding, as well as major gastrointestinal bleeding, was numerically lower at higher cTTR quartiles in warfarin-treated patients. When comparing major bleedings between dabigatran 150 mg- and warfarin-treated patients, there were benefits at lower cTTR but similar results at higher cTTR (*P*=0.03). The rates of intracranial bleeding in warfarin-treated patients were associated with the cTTR and were consistently lower in dabigatran-treated patients than warfarin-treated patients irrespective of cTTR. There was a higher rate of major gastrointestinal bleeding in dabigatran 150 mg-treated patients compared to warfarin-treated patients at higher cTTR (*P*=0.019). There was an increase in total bleeding rate with increasing cTTR with all three treatments, without any significant interactions between them.

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				Secondary: Mortality rates were 4.13, 3.75 ("superiority"; *P*<0.13) and 3.64% ("superiority"; *P*<0.051) per year in warfarin-, dabigatran 110 mg- and dabigatran 150 mg-treated patients. Total mortality was lower at higher cTTR in warfarin-treated patients; the interaction *P* value was 0.052 for the interaction between cTTR and the effects of dabigatran 110 mg and 0.066 for the effects of dabigatran 150 mg, with differences in mortality at lower cTTR but similar rates at higher cTTR. For all cardiovascular events, including total mortality and major bleeding, there were significantly lower event rates at higher cTTR in warfarin-treated patients. There was a significant interaction between cTTR and the composite of all cardiovascular events when comparing dabigatran 150 mg- and warfarin-treated patients (*P*=0.0006), and dabigatran 110 mg- and warfarin-treated patients (*P*=0.036). These interactions were mainly attributable to significant differences between treatments in the rates of nonhemorrhagic events (*P*=0.017 for dabigatran 110 mg vs warfarin and *P*=0.0046 for dabigatran 150 mg vs warfarin), with advantages at lower cTTR, whereas rates were greater at higher cTTR.
Ezekowitz et al[38] Dabigatran 50, 150, and 300 mg BID vs warfarin, dose adjusted to maintain an INR of 2.0 to 3.0 (OL) The three doses of dabigatran were combined in a 3x3 factorial fashion with no aspirin or 81 to 325 mg of aspirin QD.	DB, MC, RCT Patients with documented AF with CAD plus ≥1 of the following: hypertension requiring medical treatment, diabetes, symptomatic heart failure or left ventricular dysfunction (ejection fraction <40%), previous stroke or TIA or age >75	N=502 12 weeks	Primary: Incidence of bleeding Secondary: Suppression of D-dimer	Primary: Major bleeding events were limited to dabigatran 300 mg plus aspirin-treated patients (four patients out of 64); being statistically different compared to dabigatran 300 mg with no aspirin-treated patients (zero patients out of 150; *P*<0.02). There was a significant difference in major plus clinically relevant bleeding episodes (11 out of 64 vs six out of 105; *P*=0.03) and total bleeding episodes (25 out of 64 vs 14 out of 105; *P*=0.0003) between dabigatran 300 mg plus aspirin- and dabigatran 300 mg with no aspirin-treated patients. The frequency of bleeding in both dabigatran 50 mg treatment groups was significantly lower than that within the warfarin treatment group (seven out of 107 vs 12 out of 70; *P*=0.044). When the doses of dabigatran were compared to each other, irrespective of aspirin use, there were differences in total bleeding episodes in 300 and 150 mg- vs 50 mg-treated patients (37 out of 169 and 30 out of 169 vs seven out

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				of 107; *P*=0.0002 and *P*=0.01, respectively). Secondary: Generally, at 12 weeks, a 13% relative increase of D-dimer plasma measurements was observed in dabigatran 50 mg-treated patients (*P*=0.0008) and a 3% relative increase in dabigatran 150 mg-treated patients (*P*=0.027) was observed. No significant changes in 300 mg dabigatran- (0%; *P*=0.413) or warfarin-treated patients (-1%; *P*=0.267) were seen. Aspirin treatment had no effect on any of these analyses.
Patel et al[12] ROCKET-AF Rivaroxaban 20 mg QD (15 mg QD in patients with a creatinine clearance 30 to 49 mL/minute) vs warfarin (INR of 2.0 to 3.0)	AC, DB, DD, MC, PRO, RCT Patients with non-valvular AF, as documented on electro-cardiography, at moderate- to high-risk for stroke, indicated by a history of stroke, TIA, or systemic embolism; or ≥2 of the following risk factors: heart failure or a left ventricular ejection fraction ≤35%, hypertension, age ≥75 years, or diabetes mellitus; the proportion of patients who had not had a previous ischemic stroke, TIA, or systemic	N=14,264 590 days (median duration of treatment; 707 days median follow-up)	Primary: Composite of stroke (ischemic or hemorrhagic) and systemic embolism Secondary: Composite of stroke, systemic embolism, or death from cardiovascular causes; composite of stroke, systemic embolism, death from cardiovascular causes, or MI; individual components of composite outcomes; major and nonmajor clinically relevant bleeding events	Primary: In the PP population, stroke or systemic embolism occurred in 188 rivaroxaban-treated patients (1.7% per year) compared to 241 warfarin-treated patients (2.2% per year). Rivaroxaban was noninferior to warfarin in regard to the primary outcome (HR, 0.79; 95% CI, 0.66 to 0.96; *P*<0.001 for noninferiority). In the as-treated safety population, the primary outcome occurred in 189 (1.7% per year) and 243 (2.2% per year) rivaroxaban- and warfarin-treated patients (HR, 0.79; 95% CI, 0.65 to 0.95; *P*=0.01 for "superiority"). In the ITT population, the primary end point occurred in 269 rivaroxaban-treated patients (2.1% per year) compared to 306 patients in warfarin-treated patients (2.4% per year; HR, 0.88; 95% CI, 0.74 to 1.03; *P*<0.001 for noninferiority; *P*=0.12 for "superiority"). Secondary: In the on-treatment population, the composite of stroke, systemic embolism, or vascular death occurred in significantly fewer rivaroxaban-treated patients compared to warfarin treated patients (3.11 vs 5.79% per year, respectively; HR, 0.86; 95% CI 0.74 to 0.99; *P*=0.034). In the on-treatment population, the composite of stroke, systemic embolism, vascular death or MI occurred in significantly fewer rivaroxaban-treated patients compared to warfarin treated patients (3.91 vs 4.62% per year, respectively; HR, 0.85; 95% CI 0.74 to 0.96; *P*=0.010).

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
	embolism and who had <2 risk factors was limited to 10% of the cohort for each region; the remainder of patients were required to have had either previous thromboembolism or ≥3 risk factors			In the on-treatment population, stroke occurred in 184 (2.61%) and 221 (3.12%) rivaroxaban- and warfarin-treated patients; there was no difference in event rates between the two treatments (1.65 vs 1.96% per year; HR, 0.85; 95% CI, 0.70 to 1.03; *P*=0.092). In the on-treatment population, non-central nervous system systemic embolism occurred in five (0.07%) and 22 (0.31%) rivaroxaban- and warfarin-treated patients; the event rate was significantly lower with rivaroxaban (0.04 vs 0.19% per year; HR, 0.23; 95% CI, 0.09 to 0.61; *P*=0.003). In the on-treatment population, vascular death occurred in 170 (2.41%) and 193 (2.73%) rivaroxaban- and warfarin-treated patients; there was no difference in event rates between the two treatments (1.53 vs 1.71% per year; HR, 0.89; 95% CI, 0.73 to 1.10; *P*=0.289). In the on-treatment population, MI occurred in 101 (1.43%) and 126 (1.78%) rivaroxaban- and warfarin-treated patients; there was no difference in event rates between the two treatments (0.91 vs 1.12% per year; HR, 0.81; 95% CI, 0.63 to 1.06; *P*=0.121). There was no difference in major and clinically relevant nonmajor bleeding between rivaroxaban and warfarin. Bleeding occurred in 1,475 and 1,449 rivaroxaban- and warfarin-treated patients (14.9 and 14.5% per year, respectively; HR, 1.03; 95% CI, 0.96 to 1.11; *P*=0.44). The incidence of major bleeding was similar with rivaroxaban and warfarin (3.6 and 3.4%, respectively; *P*=0.58). Decreases in hemoglobin levels ≥2 g/dL and transfusions were more common among rivaroxaban-treated patients, whereas fatal bleeding and bleeding at critical anatomical sites were less frequent compared to warfarin treated patients. Rates of intracranial hemorrhage were significantly lower with rivaroxaban compared to warfarin (0.5 vs 0.7% per year; HR, 0.67; 95% CI, 0.47 to 0.93; *P*=0.02).

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				Major bleeding from a gastrointestinal site was more common with rivaroxaban, with 224 bleeding events (3.2%), compared to 154 events (2.2%) with warfarin (*P*<0.001).
Anderson et al[25] Warfarin (INR ≥2.0) vs placebo, antiplatelet agents (aspirin, aspirin plus clopidogrel, indobufen*), low dose warfarin and low dose warfarin plus aspirin Results for aspirin plus clopidogrel and indobufen were not reported.	MA (15 RCTs) Patients ≥18 years of age with AF or atrial flutter	N=16,058 ≥3 months	Primary: Incidence of systemic embolism and major bleeding Secondary: Not reported	Primary: *Warfarin vs placebo* Four trials compared the efficacy of warfarin vs placebo for prevention of thromboembolic events (n=1,909). Eleven systemic embolic events were observed; two and nine in warfarin- and placebo-treated patients (OR, 0.29; 95% CI, 0.08 to 1.07; *P*=0.06). The rates of major bleeding were higher in warfarin-treated patients in three trials. The combined OR for major bleeding was higher in warfarin-treated patients (OR, 3.01; 95% CI, 1.31 to 6.92; *P*=0.01). *Warfarin vs antiplatelet agents* Nine trials compared the efficacy of warfarin and antiplatelet agents for the prevention of systemic embolism (n=11,756). Thirty four and 71 systemic embolism events occurred in warfarin- and antiplatelet-treated patients (OR, 0.50; 95% CI, 0.33 to 0.75; *P*<0.001). Pooled analysis for the risk of major bleeding showed no evidence of increased risk with warfarin treatment (OR, 1.07; 95% CI, 0.85 to 1.34; *P*=0.59). *Warfarin vs low dose warfarin or a combination of low dose warfarin and aspirin* Five trials compared warfarin vs low dose warfarin or the combination of low dose warfarin and aspirin for the prevention of thromboembolic events. Four trials compared warfarin directly with low dose warfarin (n=1,008), and five and three patients had an embolic event (OR, 1.52; 95% CI, 0.40 to 5.81; *P*=0.54). Two trials compared warfarin to low dose warfarin and aspirin (n=1,385); two patients in each group had a systemic embolic event (OR, 1.00; 95% CI, 0.17 to 5.81; *P*=1.00). The risk of major bleeding was higher in warfarin-treated patients compared to low dose warfarin-treated patients (OR, 2.88; 95% CI, 1.09 to 7.60; *P*=0.03), but there was no difference when comparing warfarin-treated patients to low dose warfarin and aspirin-treated patients (OR, 1.14; 95% CI, 0.55 to 2.36; *P*=0.72). All trials were stopped early owing to the "superiority" of warfarin treatment in stroke prevention seen in other trials.

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				Secondary: Not reported
Cochrane Review (Saxena et al)[26] Oral anticoagulants (warfarin) vs placebo Target INR ranges in patients receiving oral anticoagulants were 2.5 to 4.0 and 1.4 to 2.8 in the two RCTs included in the review.	2 RCTs Patients with nonrheumatic AF and a previous TIA or minor ischemic stroke	N=485 1.7 to 2.3 years	Primary: Fatal or non-fatal recurrent stroke, all major vascular events (vascular death, recurrent stroke, MI, and systemic embolism), any intracranial bleed, major extracranial bleed Secondary: Not reported	Primary: In one RCT, the annual rate of all vascular events was eight vs 17% in oral anticoagulation and placebo-treated patients. The risk of stroke was reduced from 12 to four percent per year. In absolute terms, 90 vascular events (mainly strokes) were prevented per 1,000 patients treated with oral anticoagulation per year. There were eleven out of 225 nonvascular deaths in oral anticoagulation-treated patients compared to nine out of 214 nonvascular deaths in placebo-treated patients, and 30 out of 225 and 35 out of 214 vascular deaths. In the same trial, the incidence of all bleeding events while receiving oral anticoagulation was low (2.8 vs 0.7% per year). The absolute annual excess of major bleeds was 21 per 1,000 patients treated, with no documented intracerebral bleeding. In the second RCT, four and two placebo- and oral anticoagulation-treated patients had a recurrent stroke. The number of all vascular events was eight out of 21 in warfarin-treated patients compared to eleven out of 25 in placebo-treated patients (OR, 0.78; 95% CI, 0.20 to 2.9). In the same trial, no intracranial bleeds occurred. Combined results demonstrate that oral anticoagulation is highly effective; it reduces the odds of recurrent stroke (disabling and non-disabling) by two-thirds (OR, 0.36; 95% CI, 0.22 to 0.58) and it almost halves the odds of all vascular events (OR, 0.55; 95% CI, 0.37 to 0.82). The benefit is not negated by an unacceptable increase of major bleeding complications (OR, 4.32; 95% CI, 1.55 to 12.10). In both trials, no intracranial bleeds were reported in oral anticoagulation-treated patients (OR, 0.13; 95% CI, 0.00 to 6.49). Secondary: Not reported
Cochrane Review (Aguilar et al)[27] Oral anticoagulants	5 RCTs Patients with AF without prior stroke	N=2,313 1.5 years (mean follow-	Primary: All strokes Secondary:	Primary: Consistent reductions were likewise evident in all trials, with an overall OR of 0.39 (95% CI, 0.26 to 0.59). About 25 strokes would be prevented yearly per 1,000 patients given oral anticoagulants.

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
(warfarin [and congeners*] and orally active DTIs) vs control or placebo	or TIA	up; range, 1.2 to 2.3 years)	Ischemic strokes, all disabling or fatal stroke, MI, systemic emboli, all intracranial hemorrhage, major extracranial hemorrhage, vascular death, composite of all stroke, MI or vascular death, all-cause mortality	Secondary: Warfarin was associated with a reduction in ischemic stroke in all five trials, which was significant in four (pooled analysis vs control: OR, 0.34; 95% CI, 0.23 to 0.52). With the annualized rate of ischemic stroke in the control group of about four percent per year, the absolute reduction by oral anticoagulants was about 2.6% per year for patients without prior stroke or TIA, or about 25 ischemic strokes saved yearly per 1,000 patients given warfarin. Consistent reductions in all disabling or fatal strokes were seen in all trials, not reaching statistical significance in individual trials but with a significant reduction in pooled analysis (OR, 0.47; 95% CI, 0.28 to 0.80). About 12 of these serious strokes would be prevented yearly for every 1,000 participants given warfarin. Fifteen MIs occurred in three trials; therefore, no meaningful estimate of the effect of oral anticoagulants on this outcome could be made (OR, 0.87; 95% CI, 0.32 to 2.42). Ten systemic emboli occurred in the five trials; therefore, no meaningful estimate of the effect of oral anticoagulants could be made, but with the trend similar to that for ischemic stroke (OR, 0.45; 95% CI, 0.13 to 1.57). Seven intracranial hemorrhages occurred, with a nonsignificant trend toward the expected increase (OR, 2.38; 95% CI, 0.54 to 10.50). Major extracranial hemorrhage was similar in warfarin-treated patients, but with wide CIs due to the relatively small number of events (OR, 1.07; 95% CI, 0.53 to 2.12). A nonsignificant trend favoring treatment with warfarin was seen (OR, 0.84; 95% CI, 0.56 to 1.30) for vascular death. For the composite of stroke, MI or vascular death, the OR with oral anticoagulants was 0.57 (95% CI, 0.42 to 0.76). About 25 of these events

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				would be prevented per year for every 1,000 patients given warfarin. Sixty nine and 99 deaths occurred in warfarin- and control-treated patients (OR, 0.69; 95% CI, 0.50 to 0.94). The mortality rate averaged 5% per year in the control group. About 17 deaths would be prevented per year for every 1,000 AF patients given warfarin.
Ezekowitz et al[28] Warfarin vs aspirin vs warfarin plus aspirin A total of 10 trials were included: five primary prevention PC trials, one secondary prevention trial, one trial comparing warfarin to aspirin, and three trials of warfarin plus aspirin.	MA (10 trials) Patients with AF	N=not reported 1.2 to 2.3 years (average follow-up)	Primary: Not reported Secondary: Not reported	Primary: Not reported Secondary: Not reported Pooled analysis from the five PC, primary prevention trials demonstrate the value of warfarin for reducing the risk of stroke was consistent among trials and decreased the risk by 68% (4.5 to 1.4% per year) with virtually no increase in the frequency of major bleeding (rates: 1.2, 1.0 and 1.0% per year for warfarin, aspirin and placebo, respectively). Two of these trials evaluated aspirin for the primary prevention of stroke. In one trial, aspirin use was associated with a 42% reduction in stroke and in the other, the reduction of stroke with aspirin compared to placebo was 36%. The primary prevention trials demonstrate that warfarin is “superior” to both aspirin and placebo, with aspirin being more effective than placebo for preventing stroke. The annual rate of the main outcome measures of death due to vascular disease, any stroke, MI or systemic embolism in the secondary prevention trial was 8% per year in warfarin-treated patients and 17% per year in placebo-treated patients. Treatment with warfarin reduced the risk of stroke from 12 to 4% per year (66% reduction). Among the aspirin-treated patients, the incidence of outcome events was 15% per year compared to 19% per year among placebo-treated patients. The incidence of major bleeding was low in this trial: 2.8, 0.9 and 0.7% per year for warfarin, aspirin and placebo. In the trial comparing warfarin to aspirin for the primary prevention of stroke, the primary event rate was 1.3 and 1.9% per year in warfarin- and aspirin-treated patients (RR, 0.67; *P*=0.24), and by ITT analysis there was no

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				benefit from treatment with warfarin. Of note, the trial was not adequately powered to show a difference between the two treatments. Patients >75 years of age had a substantial risk of thromboembolism during treatment with aspirin (4.8% per year); treatment with warfarin reduced the risk to 3.6% per year (RR, 0.73; *P*=0.39). The trial evaluating warfarin in combination with aspirin to warfarin monotherapy in AF patients with at least one prespecified risk factor for thromboembolic disease was terminated after a mean follow-up of 1.1 years because the rate of ischemic stroke and systemic embolization in combination-treated patients was 7.9% per year compared to 1.9% per year in warfarin-treated patients (*P*<0.001). The rates of major bleeding were similar in both treatments.
Reduce the Risk of Death, Recurrent Myocardial Infarction and Thromboembolic Events Such as Stroke or Systemic Embolization After Myocardial Infarction				
Rothberg et al[29] Warfarin (high intensity) plus aspirin vs aspirin	MA (10 RCTs) Patients with ACS who were not stented	N=5,938 3 months to 4 years (follow-up)	Primary: MI, stroke, revascularization Secondary: Not reported	Primary: The annualized rate of MI in aspirin-treated patients ranged from 0.03 to 0.93. Nine of the ten trials found a risk reduction attributable to treatment with warfarin, but only two trials were sufficiently powered for the reduction to reach statistical significance. Reductions in RR ranged from 29 to 100%, with an overall RR of 44%. The annualized risk for ischemic stroke in aspirin-treated patients ranged from 0.000 to 0.080, with a weighted average of 0.008. In the five trials in which at least one stroke was reported, a risk reduction for warfarin plus aspirin-treated patients was found, but only one risk reduction was statistically significant. Reductions in the RR ranged from 50 to 100%, with an overall RR of 54% (CI, 23 to 73). Overall, four hemorrhagic strokes occurred in warfarin-treated patients and one in aspirin-treated patients, translating to one additional intracranial hemorrhage per 1,800 patient-years of combined anticoagulation. The annualized risk for revascularization ranged from 0.076 to 1.300. Five of the seven trials showed decreased rates of percutaneous transluminal coronary angioplasty or CABG for warfarin-treated patients, but only one rate reached statistical significance. HRs ranged from 0.51 to 1.70, with an overall RR reduction of 20% (95% CI, 5 to 33).

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				No trial showed a significant difference in mortality. The combined trials showed a four percent decrease in overall mortality in warfarin-treated patients, but this did not reach significance (*P* value not reported). Nine trials showed an increased risk for major bleeding associated warfarin treatment. The annualized risk for major bleeding in warfarin-treated patients ranged from 0.6 to 18.0%, with an overall risk of 1.5%. The RR for major bleeding with warfarin treatment compared to aspirin was 2.5 (95% CI, 1.7 to 3.7). The RR for minor bleeding was 2.6 (95% CI, 2.0 to 3.3). Secondary: Not reported
Prophylaxis and/or Treatment of Venous Thromboembolism				
Eriksson et al[13] RECORD1 Rivaroxaban 10 mg QD for 35 days vs enoxaparin 40 mg SC QD in the evening for 35 days Rivaroxaban was initiated six to eight hours after wound closure. Enoxaparin was administered 12 hours prior to surgery and then reinitiated six to eight hours after wound	DB, DD, MC, RCT Patients ≥18 years of age undergoing elective total hip replacement	N=4,541 70 days	Primary: The composite of any DVT, nonfatal PE, or death from any cause up to 36 days; incidence of major bleeding beginning after the first dose of the study drug and up to two days after the last dose of the study drug Secondary: Major VTE (composite of proximal DVT, nonfatal PE, or death from VTE), incidence of DVT (any thrombosis, including both proximal and distal), incidence of symptomatic VTE	Primary: Rivaroxaban significantly reduced the risk of the primary composite endpoint (1.1 vs 3.7%; ARR, -2.6%; 95% CI, -3.7 to -1.5; *P*<0.001). There was no difference between rivaroxaban and enoxaparin for major bleeding events (0.3 vs 0.1%; *P*=0.18). Secondary: Rivaroxaban significantly reduced the risk of major VTE (0.2 vs 2.0%; ARR, -1.7%; 95% CI, -2.5 to 1.0; *P*<0.001). Rivaroxaban significantly reduced the risk of DVT (0.8 vs 3.4%; ARR, -2.7; 95% CI, -3.7 to -1.7; *P*<0.001). Rivaroxaban and enoxaparin had similar rates of symptomatic VTE during treatment (0.3 vs 0.5%; ARR, -0.2%; 95% CI, -0.6 to 0.1; *P*=0.22) and follow-up (<0.1 vs 0.0%; ARR, -0.1%; 95% CI, -0.4 to 0.1; *P*=0.37). Both treatments had <0.1% cases of death occurring during follow-up (*P* value not reported). Rivaroxaban and enoxaparin had similar rates for any on-treatment bleeding

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
closure. All patients received either placebo tablets or placebo injection.			during treatment and follow-up, death during the follow-up period, any on-treatment bleeding, any on-treatment nonmajor bleeding, hemorrhagic wound complications, any bleeding that started after the first dose and up to two days after the last dose of the study drug, adverse events, death	(6.0 vs 5.9%; *P*=0.94) and any on-treatment nonmajor bleeding events (5.8 vs 5.8%; *P* value not reported). The rate of hemorrhagic wound complications was also similar (1.5 vs 1.7%; *P* value not reported). The rate of any bleeding beginning after the first dose of rivaroxaban or placebo were also similar (5.5 vs 5.0%; *P* value not reported). Rivaroxaban and enoxaparin had similar rates of any on-treatment adverse event (64.0 vs 64.7%; *P* value not reported). The incidence of death during the on-treatment period was similar between the two treatments (0.3 vs 0.3%; ARR, 0%; 95% CI, -0.4 to 0.4; *P*=1.00). Of the four deaths that occurred with rivaroxaban, two were possibly related to VTE. Of the four deaths that occurred with enoxaparin, one was related to VTE.
Kakkar et al[14] RECORD2 Rivaroxaban 10 mg QD for 31 to 39 days vs enoxaparin 40 mg SC QD for 10 to 14 days Rivaroxaban was initiated six to eight hours after wound closure. Enoxaparin was administered 12 hours prior to surgery and reinitiated six to eight hours after wound closure.	DB, DD, MC, RCT Patients ≥18 years of age undergoing complete hip replacement	N=2,509 75 days	Primary: The composite of any DVT, nonfatal PE, or death from any cause up to day 30 to 42; incidence of major bleeding beginning after the first dose of the study drug and up to two days after the last dose of the study drug Secondary: Major VTE, (composite of proximal DVT, nonfatal PE, or death from VTE), incidence of DVT (any thrombosis, including both proximal and distal), incidence of symptomatic VTE	Primary: Rivaroxaban significantly reduced the risk of the primary composite endpoint compared to enoxaparin (2.0 vs 9.3%; ARR, 7.3%; 95% CI, 5.2 to 9.4; *P*<0.0001). Major bleeding occurred at a rate <0.1% with both rivaroxaban and enoxaparin (*P* value not reported). The one major bleeding event with enoxaparin was deemed unrelated to the treatment drug by the adjudication committee. Secondary: Rivaroxaban significantly reduced the risk of major VTE (0.6 vs 5.1%; ARR, 4.5%; 95% CI, 3.0 to 6.0; *P*<0.0001). Rivaroxaban significantly reduced the risk of DVT (1.6 vs 8.2%; ARR, 6.5%; 95% CI, 4.5 to 8.5; *P*<0.0001). Rivaroxaban significantly reduced the risk of on-treatment symptomatic VTE (0.2 vs 1.2%; ARR, 1.0%; 95% CI, 0.3 to 1.8; *P*=0.004); however, the rates during follow-up were similar (0.1 vs 0.2%; ARR, 0.1%; 95% CI, -0.2 to 0.4; *P*=0.62).

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
All patients received either placebo tablets or placebo injection.			during treatment and follow-up, death during the follow-up period, any on-treatment bleeding, any on-treatment nonmajor bleeding, hemorrhagic wound complications, any postoperative bleeding that started after the first dose and up to two days after the last dose of the study drug, adverse events, death	The incidence of death during the follow-up period was similar between the two treatments (0.0 vs 0.2%; ARR, 0.2%; 95% CI, -0.1 to 0.6; *P*=0.50). Rates of any on-treatment bleeding (6.6 vs 5.5%; *P* value not reported) and any on-treatment nonmajor bleeding (6.5 vs 5.5%; *P* value not reported) were similar between the two treatments. Hemorrhagic wound complications also occurred at similar rates (1.6 vs 1.7%; *P* value not reported). The rate of any bleeding beginning after initiation of rivaroxaban or placebo was also similar (4.7 vs 4.1%; *P* value not reported). Adverse events from any cause were similar between the two treatments (62.5 vs 65.7%; *P* values not reported). The incidence of on-treatment death was similar between the two treatments (0.2 vs 0.7%; ARR, 0.5%; 95% CI, -0.2 to 1.1; *P*=0.29).
Lassen et al[15] RECORD3 Rivaroxaban 10 mg QD for 10 to 14 days vs enoxaparin 40 mg SC QD for 10 to 14 days Rivaroxaban was initiated six to eight hours after wound closure. Enoxaparin as administered 12 hour preoperatively and reinitiated six to eight hours after wound	DB, DD, MC, RCT Patients ≥18 years of age undergoing elective total knee replacement	N=2,531 49 days	Primary: The composite of any DVT, nonfatal PE, or death from any cause within 13 to 17 days post surgery; incidence of major bleeding beginning after the first dose of the study drug and up to two days after the last dose of the study drug Secondary: Major VTE (composite of proximal DVT, nonfatal PE, or death from VTE), incidence of DVT (any thrombosis, including both proximal	Primary: Rivaroxaban significantly reduced the risk of the primary composite endpoint compared to enoxaparin (9.6 vs 18.9%; ARD, -9.2%; 95% CI, -12.4 to -5.9; *P*<0.001). The rate of major bleeding was similar between the two treatments (0.6 vs 0.5%; *P*=0.77). Secondary: Rivaroxaban significantly reduced the risk of major VTE (1.0 vs 2.6%; ARD, -1.6%; 95% CI, -2.8 to -0.4; *P*=0.01). Rivaroxaban significantly reduced the risk of DVT (9.6 vs 18.2%; ARD, -8.4; 95% CI, -11.7 to -5.2; *P*<0.001). Rivaroxaban significantly reduced the risk of on-treatment symptomatic VTE (0.7 vs 2.0%; ARD, -1.3%; 95% CI, -2.2 to -0.4; *P*=0.005); however, during follow-up the rates were similar (0.4 vs 0.2%; ARD, 0.2%; 95% CI, -0.3 to 0.6; *P*=0.44). The incidence of death during follow-up was similar between the two

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
closure. All patients received either placebo tablets or placebo injection.			and distal), incidence of symptomatic VTE during treatment and follow up, death during the follow up period, any on-treatment bleeding or any major bleeding occurring between intake of the first dose of the study medication and two days after the last dose, nonmajor bleeding, adverse events, death	treatments (ARD, -0.2%; 95% CI, -0.6 to 0.2; *P*=0.21). Rates of any on-treatment bleeding (4.9 vs 4.8%; *P*=0.93) or any major bleeding between the start of treatment and two days after the last dose (0.6 vs 0.5%; *P*=0.77) were similar between the two treatments. The rate of nonmajor bleeding was also similar (4.3 vs 4.4%; *P* value not reported). The rates of drug-related adverse events were similar between the two treatments (12 vs 13%; *P* value not reported). The incidence of death during treatment was similar between the two treatments (0.0 vs 0.2%; ARD, -0.2%; 95% CI, -0.8 to 0.2; *P*=0.23)
Turpie et al[16] RECORD4 Rivaroxaban 10 mg QD for 10 to 14 days vs enoxaparin 30 mg SC BID for 10 to 14 days Rivaroxaban was initiated six to eight hours after wound closure. Enoxaparin was initiated 12 to 24 hours after wound closure. All patients received either placebo tablets	DB, DD, MC, RCT Patients ≥18 years of age undergoing total knee replacement	N=3,148 49 days	Primary: The composite of any DVT, nonfatal PE, or death from any cause 17 days after surgery; incidence of major bleeding beginning after the first dose of the study drug and up to two days after the last dose of the study drug Secondary: Major VTE (composite of proximal DVT, nonfatal PE, or death from VTE), incidence of asymptomatic DVT (any thrombosis, including both proximal and distal), incidence of	Primary: Rivaroxaban significantly reduced the risk of the primary composite endpoint compared to enoxaparin (6.9 vs 10.1%; ARD, -3.19%; 95% CI, -5.67 to -0.71; *P*=0.0118). There was no difference in the rate of major bleeding between the two treatments (0.7 vs 0.3%; *P*=0.1096). Secondary: Rivaroxaban did not reduce the risk of major VTE compared to enoxaparin (1.2 vs 2.0%; ARD, -0.80; 95% CI, -1.34 to 0.60; *P*=0.1237). The rates of asymptomatic DVT were similar between the two treatments (*P* value not reported). Rivaroxaban did not reduce the risk of symptomatic VTE on-treatment (0.7 vs 1.2%; ARD, -0.47; 95% CI, -1.16 to 0.23; *P*=0.1868) or during follow-up (0.2 vs 0.2%; ARD, 0.00%; 95% CI, -0.32 to 0.32; *P*=0.9979). The incidence of death during follow-up was similar between the two treatments (0.3 vs 0.2%; ARD, 0.06%; 95% CI, -0.35 to 0.50; *P*=0.8044).

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
or placebo injection.			symptomatic VTE during treatment and follow up, death during the follow-up period, clinically relevant nonmajor bleeding, any on-treatment bleeding, any nonmajor bleeding, hemorrhagic wound complications, adverse events, death	The rates of clinically relevant nonmajor bleeding (10.2 vs 9.2%; *P* value not reported) and any on-treatment bleeding (10.5 vs 9.4%; *P*=0.3287) were similar between the two treatments. The rate of hemorrhagic wound complications was also similar (1.4 vs 1.5%; *P* value not reported). The rates of drug-related adverse events were similar between the two treatments (20.3 vs 19.6%; *P* value not reported). The rates of on-treatment death were similar between the two treatments (0.1 vs 0.2%; *P*=0.7449).
Cochrane Review (Hutten et al)[30] Oral anticoagulants (dicoumarol*, warfarin) Trials were included if different durations of treatment with a VKA were compared. The eight trials compared seven different periods of treatment with VKAs: four weeks vs three months, six vs 12 weeks, six weeks vs six months, three vs six months, three months vs one year, three vs 27 months, and six months vs four years.	8 trials Patients with symptomatic VTE	N=2,994 Duration varied	Primary: Recurrent VTE Secondary: Major bleeding, mortality	Primary: All trials reported on the occurrence of symptomatic VTE during the period from cessation in VKA-treated patients in the short duration arm until cessation of treatment in the long duration arm. Four trials demonstrated a significant protection from recurrent VTE complications during prolonged treatment with VKAs, while the others revealed a clear trend. In the combined analysis of all eight trials, a significant reduction in thromboembolic events during prolonged treatment was observed (116 out of 1,495 short duration vs 14 out of 1,499 long duration; OR, 0.18; 95% CI, 0.13 to 0.26). Six trials evaluated the incidence of recurrent VTE in the period after cessation of study medication. No trial demonstrated a significant increase in VTE events among participants in the long arm after cessation of treatment, and combined analysis demonstrated similar results (96 out of 1,304 long duration vs 78 out of 1,301 short duration; OR, 1.24; 95% CI, 0.91 to 1.69). Analyses of pooled data demonstrated a significant reduction in recurrent VTE for the following comparisons: four weeks vs three months (OR, 0.23; 95% CI, 0.06 to 0.70), three vs six months (OR, 0.13; 95% CI, 0.05 to 0.33) and three vs 12 months (OR, 0.22; 95% CI, 0.11 to 0.44). Secondary: Four trials reported the incidence of major bleeding during the period from cessation of treatment with VKAs in the short duration arm until cessation of

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				treatment in the long duration arm. No trial demonstrated a significant increase in bleeding complications during prolonged treatment, but combined results demonstrated a significant increase in major bleeding complications during this period (one out of 405 short duration vs eight out of 403 long duration; OR, 4.87; 95% CI, 1.31 to 18.15). Only one trial reported the incidence of major bleeding in the period after cessation of study medication. All trials reported on the occurrence of major bleeding complications for the entire period after randomization until the end of follow-up. No trial demonstrated a significant increase during prolonged treatment, but combined results demonstrated a significant increase during this period (36 out of 1,499 long duration vs 13 out of 1,495 short duration; OR, 2.61; 95% CI, 1.48 to 4.61). Three trials reported mortality during the period from cessation of treatment with VKAs in the short duration arm until cessation of treatment in the long duration arm. One trial demonstrated a non-significant decrease in mortality during prolonged treatment, while the others showed no trends. Combined results demonstrated a non-significant reduction in mortality favoring prolonged treatment (12 out of 188 short duration vs 10 out of 188 long duration; OR, 0.80; 95% CI, 0.34 to 1.91). All trials reported on mortality for the entire period after randomization, with none demonstrating a significant reduction in morality. When the results were combined, a nonsignificant reduction in mortality during the entire study period was observed (71 out of 1,498 long duration vs 75 out of 1,496 short duration; OR, 0.93; 95% CI, 0.67 to 1.30).
Cochrane Review (van der Heijden et al)[31] VKAs vs	7 RCTs Patients with symptomatic DVT receiving long-term treatment	N=1,137 3 to 9 months	Primary: Recurrent symptomatic VTE, major bleeding complications, mortality Secondary:	Primary: All seven trials reported the occurrence of recurrent symptomatic VTE during the first three to six months after randomization. Six trials showed no differences between treatment with LMWH and VKAs, and one trial found a significant OR of 0.38 (95% CI, 0.17 to 0.86) in favor of treatment with LMWH. When the seven trials are combined, the rate of recurrent symptomatic VTE was 6.7 vs 4.8% in VKA- and LMWH-treated patients, corresponding to a nonsignificant reduction in favor of LMWH (OR, 0.70;

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
LMWH			Not reported	95% CI, 0.42 to 1.16). Six trials evaluated the occurrence of recurrent symptomatic VTE during a period of six to nine months after cessation of the allocated treatment. The rate of recurrent symptomatic VTE was 3.5 vs 5.0% of VKA- and LMWH-treated patients, corresponding to nonsignificant difference in favor of VKA treatment (OR, 1.46; 95% CI, 0.80 to 2.69). All seven trials reported the incidence of major bleeding during allocated treatment, with six trials finding no difference between the two treatments and one finding a significant difference in favor of treatment with LMWH (OR, 0.12; 95% CI, 0.02 to 0.89). When the trials were combined, 2.5 vs 0.9% VKA- and LMWH-treated patients had a major bleed; a significant difference in favor of treatment with LMWH (OR, 0.38; 95% CI, 0.15 to 0.94). No major bleeding occurred in the additional nine months of follow-up. All seven trials reported on mortality during the allocated treatment, with the individual trials not finding a significant difference between the two treatments. In the combined analysis, 2.5 vs 3.7% of VKA- and LMWH-treated patients died (OR, 1.51; 95% CI, 0.77 to 2.97). Six trials extended the follow-up period for an additional six to nine months and found that the rate of death was 3.5 vs 3.9% (OR, 1.11; 95% CI, 0.58 to 2.15). Secondary: Not reported
Cochrane Review (Salazar et al)[32] DTI (dabigatran†, desirudin, ximelagatran*) vs warfarin or LMWH (dalteparin,	12 RCTs Patients who have undergone total hip replacement or total knee replacement	N=21,642 (efficacy) N=27,360 (safety) Duration varied	Primary: Mortality associated with VTE, incidence of proximal VTE, mortality associated with treatment, appearance of serious hepatopathy, appearance of other serious adverse effects associated with	Primary and Secondary end points are reported together in the groupings below. *Major, total and symptomatic VTE* Combined analysis from two trials comparing DTIs to LMWH demonstrated that when evaluating the combination of both surgery groups, no difference was observed between the two treatments (557 out of 10,736 vs 392 out of 6,692 events/patients; OR, 0.91; 95% CI, 0.69 to 1.19). Evaluation of the individual surgery groups had similar results. No difference was observed between the two treatments for total VTE (data not reported) or symptomatic VTE (234 out of 12,056 vs 143 out of 7,563; OR, 1.04; 95% CI, 0.84 to

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
enoxaparin)			treatment Secondary: Incidence of distal VTE, presence of hepatopathy after treatment, morbidity associated with treatment	1.29). Combined analysis from three trials comparing ximelagatran to warfarin demonstrated no statistical difference between the two treatments (95 out of 2,498 vs 83 out of 1,829 events/patients; OR, 0.85; 95% CI, 0.63 to 1.15). There were fewer total VTE events in DTI-treated patients (555 out of 2,514 vs 543 out of 1,840; OR, 0.68; 95% CI, 0.59 to 0.78). No difference between the two treatments were observed for symptomatic VTE (47 out of 3,022 vs 48 out of 2,237; OR, 0.80; 95% CI, 0.53 to 1.21). *Major/significant and total bleeding events* Combined analysis from eleven trials comparing DTIs to LMWH demonstrated a nonsignificant higher number of major significant bleeding events in DTI-treated patients (334 out of 13,753 vs 138 out of 8,356 events/patients; OR, 1.17; 95% CI, 0.87 to 1.58). In the comparison of each independent dose, only dabigatran 225 mg BID showed more bleeding events in the DTI group (OR, 1.90; 95% CI, 1.05 to 3.44) in the combination of both surgeries and specifically in total hip replacement (26 out of 270 vs 13 out of 270; OR, 2.11; 95% CI, 1.06 to 4.19). Combined analysis from ten trials demonstrated no difference between the two treatments in terms of total bleeding events; however, more events were observed in DTI-treated patients undergoing total hip replacement (2,370 out of 5,949 vs 1,374 out of 4,378; OR, 1.40; 95% CI, 1.06 to 1.85). Combined analysis of three trials comparing ximelagatran to warfarin demonstrated more major/significant bleeding events with ximelagatran, but the difference was not statistically significant (30 out of 3,022 vs 13 out of 2,237 events/patients; OR, 1.76; 95% CI, 0.91 to 3.38). Partial and total bleeding events were very similar to major bleeding events. *All-cause mortality* Combined analysis of eleven trials comparing DTIs to LWMH demonstrated a nonsignificant higher all-cause mortality event rate with DTI treatment (15 out of 13,730 vs four out of 8,335 events/patients; OR, 1.72; 95% CI, 0.68 to 4.35). When including follow-up events the difference met statistical significance (41 out of 13,730 vs 11 out of 8,335; OR, 2.06; 95% CI, 1.10 to

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				3.87). Combined analysis of three trials comparing ximelagatran to warfarin demonstrated no significant difference between the two treatments (six out of 3,013 vs four out of 2,230 events/patients; OR, 1.19; 95% CI, 0.36 to 4.01), even when follow-up events were included (10 out of 3,013 vs five out of 2,230; OR, 1.62; 95% CI, 0.57 to 4.58). *ALT greater than three times the upper normal limit* The seven trials comparing DTIs to LMWH had high heterogeneity; therefore, results could not be combined. Fewer events were observed in DTI-treated patients, but with high heterogeneity, in the ximelagatran trials. No difference was noted when treatment with dabigatran was compared to treatment with LMWH, but these trials had very high heterogeneity. Combined analysis of two trials comparing ximelagatran to warfarin demonstrated no significant difference between the two treatments (18 out of 2,493 vs 21 out of 1,768 events/patients; OR, 0.52; 95% CI, 0.27 to 0.97), even when follow-up events were included (11 out of 2,484 vs one out of 1,783; OR, 5.61; 95% CI, 1.00 to 31.64). *Volume of blood loss* No difference was observed between treatment with DTIs and LMWH in the combined analysis of five trials (n=8,782; WMD, 5.12; 95% CI, -33.81 to 44.04), but these trials had high heterogeneity. No difference was observed between ximelagatran and warfarin in the combined analysis of three trials (n=5,259; WMD, -7.12; 95% CI, -17.08 to 2.84), with no heterogeneity. *Time effect of the beginning of anticoagulation* Trials comparing DTIs to LMWH that began anticoagulation before surgery demonstrated fewer major (OR, 0.54; 95% CI, 0.35 to 0.83) and total (OR, 0.72; 95% CI, 0.63 to 0.82) VTE in DTI-treated patients in both surgery groups. There was also no difference regarding symptomatic VTE. Trials that began anticoagulation after surgery demonstrated more major (OR,

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				1.68; 95%, 1.12 to 2.52) and total (OR, 1.29; 95% CI, 0.69 to 2.39) VTE events in DTI-treated patients in both surgery groups. Again, there was no difference regarding symptomatic VTE. Trials that began anticoagulation before surgery demonstrated a non-significant greater incidence of major (OR, 1.64; 95% CI, 0.85 to 3.15) and total (OR, 1.45; 95% CI, 0.93 to 2.28) bleeding events in DTI-treated patients in both combined surgeries and in the individual analysis of each surgery. There was no significant difference regarding mortality. *Extended prophylactic anticoagulation vs standard prophylactic anticoagulation* No difference was found in major or total VTE between DTI- and LMWH-treated patients. Symptomatic VTE events in extended anticoagulation occurred more with dabigatran in comparison to LMWH, but the difference was not statistically significant (25 out of 2,293 vs five out of 1,142 events/patients; OR, 2.51; 95% CI, 0.96 to 5.67). In standard anticoagulation, no difference between DTI- and LMWH-treated patients was noted (76 out of 3,351 vs 37 out of 1,542; OR, 0.99; 95% CI, 0.67 to 1.48). Regarding safety, no difference in major or total bleeding events was noted. All-cause mortality, transaminase levels and blood loss were not evaluated.
Brookenthal et al[33] Thromboprophylaxis (aspirin, dextran, heparin [with or without antithrombin III], LMWH [ardeparin*, enoxaparin, tinzaparin], lower extremity pneumatic compression stockings, or warfarin)	MA (14 trials) Patients receiving prophylaxis for ≥7 days for an elective total knee arthroplasty	N=3,482 Duration varied	Primary: Total DVT, proximal DVT, distal DVT, symptomatic PE, fatal PE, minor bleeding, major bleeding, total bleeding, intracranial hemorrhage, non-PE mortality, all-cause mortality Secondary:	Primary: For total DVT, all treatments, except dextran and aspirin, protected significantly better than placebo (*P*<0.0001). For proximal DVT, no comparison against placebo was available, and rates ranged from 1.7 (aspirin) to 12.8% (SC heparin/antithrombin III). The only significant difference was between treatment with LMWH and warfarin (5.9 vs 10.2%; *P*=0.0002). There was a strong trend that aspirin protected better than warfarin (1.7 vs 10.2%; *P*=0.0106). For distal DVT, no comparison against placebo was available. LMWH (24.4%) protected significantly better than dextran (71.1%; *P*=0.0001),

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
vs placebo A prophylactic agent of interest was compared to another method of interest or placebo.			Not reported	warfarin (35.6%; *P*=0.0001) and aspirin (55.2%; *P*=0.0001). Warfarin (35.6%) protected significantly better than aspirin (55.2%; *P*=0.0045) but worse than SC heparin (21.5%; *P*=0.0029). Aspirin (55.2%) protected significantly less than SC heparin (21.5%; *P*=0.0001) and pneumatic compression stockings (29.5%; *P*=0.0051). Rates of symptomatic PE ranged from 0.0 (aspirin, pneumatic compression stockings and placebo) to 0.4% (warfarin, SC heparin); there was no significant detectable difference among the agents. No fatal PE occurred with any treatment. The rate of total bleeding ranged from 8.6 (aspirin) to 18.9% (SC heparin). No comparison with placebo was available. The rate of minor bleeding ranged from 8.6 (aspirin) to 18.3% (SC heparin). Rates of major bleeding ranged from 0.0 (aspirin, pneumatic compression stockings) to 2.4% (LWMH), but no difference between treatments were noted. There were no observed intracranial hemorrhages. Rates for overall and non-PE mortality ranged from 0.0 (aspirin, SC heparin, pneumatic compression stockings, placebo, SC heparin/antithrombin III and dextran) to 0.3% (warfarin), but no difference among the treatments were noted. Secondary: Not reported
Cochrane Review (Cundiff et al)[34] Anticoagulants (heparin, phenprocoumon*,	2 RCTs Patients with DVT or PE	N=113 3 months	Primary: Mortality due to PE, PE, DVT and extension of DVT or both Secondary:	Data were not pooled because of heterogeneity between the trials, and the trials were too small to determine any difference in mortality, occurrence of PE, and progression or return of DVT between patients receiving anticoagulation and those who were not. Primary:

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
warfarin) vs NSAIDs (phenylbutazone*) or placebo			All-cause mortality, major hemorrhagic events, fatal hemorrhagic events, morbidity and mortality due to HIT with thrombosis	In one trial (n=23), no deaths due to PE were reported and in the other trial (n=90), there was no significant difference in deaths due to PE between anticoagulant- and NSAID-treated patients (one vs zero; RR, 2.63; 95% CI, 0.11 to 62.95). In one trial (n=23), there was no difference in the combined outcome PE, DVT progression or return in anticoagulation-treated patients compared to those who did not receive anticoagulation (five vs five; RR, 1.09; 95% CI, 0.43 to 2.77). In one trial (n=90), there was no difference in the combined outcome recurrent DVT or DVT (18 vs 22; RR, 0.72; 95% CI, 0.45 to 1.14). Secondary: There was no difference in the secondary outcomes of all-cause mortality and major hemorrhage in either trial between the two treatments. Neither trial reported morbidity or mortality due to HIT with thrombosis, or VKA necrosis.

*Not available in the United States.
†Not Food and Drug Administration approved for this indication.
Drug regimen abbreviations: BID=twice daily, SC=subcutaneous, QD=once daily
Study abbreviations: AC=active control, ARD=absolute risk difference, ARR=absolute risk reduction, CI=confidence interval, DB=double-blind, DD=double dummy, HR=hazard ratio, ITT=intention-to-treat, MA=meta analysis, MC=multicenter, OL=open-label, OR=odds ratio, PC=placebo-controlled, PP=per-protocol, PRO=prospective, RCT=randomized controlled trial, RR=relative risk, WMD=weighted mean difference
Miscellaneous abbreviations: ACS=acute coronary syndrome, AF=atrial fibrillation, ALT=alanine transaminase, CABG=coronary artery bypass graft surgery, CAD=coronary artery disease, cTTR=center's mean time in therapeutic range, DTI=direct thrombin inhibitor, DVT=deep vein thrombosis, HIT=heparin induced thrombocytopenia, INR=International Normalized Ratio, LMWH=low molecular weight heparin, MI=myocardial infarction, NSAID=nonsteroidal anti-inflammatory drug, NYHA=New York Heart Association, PE=pulmonary embolism, TIA=transient ischemic attack, TTR=time in therapeutic range, VKA=vitamin k antagonist, VTE=venous thromboembolism

Special Populations

Table 5. Special Populations[1-3,5,6]

Generic Name	Population and Precaution				
	Elderly/ Children	Renal Dysfunction	Hepatic Dysfunction	Pregnancy Category	Excreted in Breast Milk
Dabigatran etexilate mesylate	No dosage adjustment required in the elderly. Safety and efficacy in children have not been established.	Renal dosage adjustment is required; for creatinine clearances 15 to 30 mL/minute, a dose of 75 mg and a dosing frequency of twice-daily are recommended. Dosing recommendations for patients with creatinine clearance <15 mL/minute or on dialysis cannot be provided.	Not reported	C	Unknown
Rivaroxaban	No dosage adjustment required in the elderly. Safety and efficacy in children have not been established.	Renal dosage adjustment is required; for creatinine clearances 15 to 50 mL/minute, a dose of 15 mg is recommended (atrial fibrillation only). Avoid use in patients with severe renal dysfunction (creatinine clearance <30 mL/minute).*	No dosage adjustment required. Avoid use in patients with moderate or severe hepatic dysfunction or with any hepatic disease associated with coagulopathy.	C	Unknown
Warfarin	Caution should be observed with administration to elderly patients in any situation or physical condition where added risk of hemorrhage is present. Safety and efficacy in	No dosage adjustment required.	No dosage adjustment required. Hepatic dysfunction can potentiate the response to warfarin through impaired synthesis of clotting factors and decreased	X	Not reported

Generic Name	Population and Precaution				
	Elderly/ Children	Renal Dysfunction	Hepatic Dysfunction	Pregnancy Category	Excreted in Breast Milk
	children have not been established.†		metabolism of warfarin.		

*Restriction only applies when used for prophylaxis of deep vein thrombosis.
†The use of warfarin in pediatric patients is well documented for the prevention and treatment of thromboembolic events.

Adverse Drug Events

The data presented in Table 6 outlines the number of patients experiencing a serious bleeding event during the treatment period in the Randomized Evaluation of Long-Term Anticoagulation Therapy (RE-LY) trial, with the bleeding rate per 100 patient years (%).[1] The rates of bleeding per 100 patients years with rivaroxaban compared to placebo in the Rivaroxaban Once Daily Oral Direct Factor Xa Inhibition Compared to Vitamin K Antagonism for Prevention of Stroke and Embolism Trial in Atrial Fibrillation (ROCKET AF) are outlined in Table 7, and the rates of major and any bleeding events observed in the Regulation in Orthopedic Surgery to Prevent Deep Vein thrombosis and Pulmonary Embolism (RECORD) trials are outlined in Table 8.[2] Table 9 outlines the adverse events of warfarin according to the approved package labeling.[3]

Table 6. Bleeding Events in the RE-LY Trial (per 100 Patient Years)*[1]

Bleeding Event	Reported Frequency	
	Dabigatran Etexilate Mesylate, 150 mg Twice Daily; n (%), N=6,067	Warfarin; n (%), N=6,022
Any bleed	1,993 (16.6)	2,166 (18.4)
Intracranial hemorrhage	38 (0.3)	90 (0.8)
Life-threatening bleed	179 (1.5)	218 (1.9)
Major bleed	399 (3.3)	421 (3.6)

*Patients contributed multiple events and events were counted in multiple categories.

Table 7. Bleeding Events in the ROCKET-AF Trial (per 100 Patient Years)[2]

Bleeding Event	Reported Frequency	
	Rivaroxaban, 20 mg Once Daily; n (%), N=7,111	Warfarin; n (%), N=7,125
Bleeding into critical organ*	91 (0.8)	133 (1.2)
Bleeding requiring ≥2 units of whole or packed red blood cells	183 (1.7)	149 (1.3)
Fatal bleeding	27 (0.2)	55 (0.5)
Gastrointestinal bleeding	221 (2)	140 (1.2)
Major bleeding†	395 (3.6)	386 (3.5)

*The majority of the events were intracranial, and also included intraspinal, intraocular, pericardial, intraarticular, intramuscular with compartment syndrome, or retroperitoneal.
†Defined as clinically overt bleeding associated with a decrease in hemoglobin of at least 2 g/dL, transfusion of at least two units of packed red blood cells or whole blood, bleeding at a critical site, or with a fatal outcome. Hemorrhagic strokes are counted as both bleeding and efficacy events. Major bleeding events excluding strokes are 3.3 per 100 patient years for rivaroxaban vs 2.9 per 100 patient years for warfarin.

Table 8. Bleeding Events in the RECORD1, RECORD2, and RECORD3 Trials* (%)[2]

Bleeding Event(s)	Rivaroxaban n (%)	Enoxaparin† n (%)
Total Patients	**N=4,487**	**N=4,524**
Any bleeding event‡	261 (5.8)	251 (5.6)
Major bleeding event	14 (0.3)	9 (0.2)
• Bleeding into a critical organ	2 (<0.1)	3 (0.1)

Bleeding Event(s)	Rivaroxaban n (%)	Enoxaparin† n (%)
Total Patients	**N=4,487**	**N=4,524**
• Bleeding that required reoperation	7 (0.2)	5 (0.1)
• Extra-surgical site bleeding requiring transfusion of >2 units of whole blood or packed cells	4 (0.1)	1 (<0.1)
• Fatal bleeding	1 (<0.1)	0
Hip Surgery	**N=3,281**	**N=3,298**
Any bleeding event‡	201 (6.1)	191 (5.8)
Major bleeding event	7 (0.2)	3 (0.1)
• Bleeding into a critical organ	1 (<0.1)	1 (<0.1)
• Bleeding that required re-operation	2 (0.1)	1 (<0.1)
• Extra-surgical site bleeding required transfusion of >2 units of whole blood or packed cells	3 (0.1)	1 (<0.1)
• Fatal bleeding	1 (<0.1)	0
Knee Surgery	**N=1,206**	**N=1,226**
Any bleeding event‡	60 (5)	60 (4.9)
Major bleeding event	7 (0.6)	6 (0.5)
• Bleeding into a critical organ	1 (0.1)	2 (0.2)
• Bleeding that required reoperation	5 (0.4)	4 (0.3)
• Extra-surgical site bleeding required transfusion of >2 units of whole blood or packed cells	1 (0.1)	0
• Fatal bleeding	0	0

*Bleeding events occurring any time following the first dose of double-blind study medication (which may have been prior to administration of active drug) until two days after the last dose of the double-blind study medication. Patients may have more than one event.
†Includes the placebo-controlled period for RECORD2, enoxaparin dosing was 40 mg once daily (RECORD1 to 3).
‡Includes major bleeding events.

Table 9. Adverse Events[3]

Adverse Event	Warfarin
Abdominal pain	✔
Alopecia	✔
Bloating	✔
Chills	✔
Cholestatic hepatitis	✔
Cholesterol microemboli	✔
Dermatitis	✔
Diarrhea	✔
Elevated liver enzymes	✔
Flatulence	✔
Hemorrhage	✔
Hepatitis	✔
Hypersensitivity/allergic reactions	✔
Nausea	✔
Necrosis of the skin	✔
Pruritis	✔
Rash	✔
Systemic atheroemboli	✔
Taste perversion	✔
Tracheal or tracheobronchial calcification	✔
Vomiting	✔

✔ Percent not specified.

According to the Food and Drug Administration package labeling for dabigatran etexilate mesylate the risk of major bleeds was similar with dabigatran etexilate mesylate 150 mg and warfarin across major subgroups defined by baseline characteristics, with the exception of age, where there was a trend towards a higher incidence of major bleeding on dabigatran etexilate mesylate (hazard ratio [HR], 1.2; 95% confidence interval [CI], 1.0 to 1.4) for patients ≥75 years of age. There was a higher rate of major gastrointestinal bleeds and any gastrointestinal bleeds in patients receiving dabigatran etexilate mesylate 150 mg than in patients receiving warfarin (1.6 vs 1.1%, respectively; HR, 1.5; 95% CI, 1.2 to 1.9; and 6.1 vs 4.0%, respectively). In addition, patients receiving dabigatran etexilate mesylate 150 mg had an increased incidence of gastrointestinal adverse reactions compared to warfarin (35 vs 24%).[1]

Other adverse events occurring more often with rivaroxaban compared to enoxaparin include wound secretions, muscle spasms, pain in extremities, syncope, blisters, and pruritus.[2,5,6]

Contraindications/Precautions

Dabigatran etexilate mesylate and rivaroxaban are contraindicated with active pathological bleeding or history of a serious hypersensitivity reaction to the medication.[1,2] Warfarin is contraindicated in any localized or general physical condition or personal circumstance in which the hazard of hemorrhage might be greater than the potential clinical benefits of anticoagulation (e.g., pregnancy, hemorrhagic tendencies or blood dyscrasias, threatened abortion, inadequate laboratory facilities, unsupervised patients with senility, spinal puncture). Warfarin is also contraindicated with recent or contemplated surgery of the central nervous system or eye, and in traumatic surgery resulting in large open surfaces. In addition, warfarin is contraindicated with bleeding tendencies associated with active ulceration or overt bleeding of gastrointestinal, genitourinary, or respiratory tracts; cerebrovascular hemorrhage; aneurysms-cerebral or dissecting aorta; pericarditis and pericardial effusions; and bacterial endocarditis. Other miscellaneous contraindications associated with warfarin include major regional, lumbar block anesthesia, malignant hypertension, and known hypersensitivity to warfarin or to any other components of this product.[3]

Dabigatran etexilate mesylate and rivaroxaban increase the risk of bleeding and can cause significant and, sometimes, fatal bleeding. Risk factors for bleeding include the use of drugs that increase the risk of bleeding in general (e.g., platelet inhibitors, heparin, fibrinolytic therapy and chronic use of nonsteroidal anti-inflammatory drugs), and labor and delivery. Patients should be promptly evaluated for any signs or symptoms of blood loss, and treatment should be discontinued in patients with active pathological bleeding.[1,2] Discontinuing anticoagulants, including dabigatran etexilate mesylate, for active bleeding, elective surgery, or invasive procedures places a patient at an increased risk of stroke. Lapses in therapy should be avoided, and if anticoagulation with dabigatran etexilate mesylate must be temporarily discontinued for any reason, therapy should be restarted as soon as possible.[1]

When neuraxial anesthesia or spinal puncture is employed, patients receiving anticoagulation for thromboprophylaxis are at risk of developing an epidural or spinal hematoma which can result in long-term or permanent paralysis. Because of this, an epidural catheter should not be removed earlier than 18 hours after the last dose of rivaroxaban, and the next dose of rivaroxaban is not to be administered earlier than six hours after the removal of the catheter. If traumatic puncture occurs, delay the administration of rivaroxaban for 24 hours.[2]

The most serious risks associated with warfarin are hemorrhage in any tissue or organ and, less frequently, necrosis and/or gangrene of skin and other tissues. Increased caution should be observed when warfarin is administered in the presence of any predisposing condition where added risk of hemorrhage, necrosis and/or gangrene is present. These and other risks associated with anticoagulant therapy must be weighed against the risk of thrombosis or embolization in untreated cases.[3,5,6]

It cannot be overemphasized that treatment with warfarin is a highly individualized matter. Warfarin, a narrow therapeutic range drug, may be affected by factors such as other drugs and dietary vitamin K. Dosage should be controlled by periodic determinations of prothrombin time/International Normalized Ratio.[3,5,6]

Therapy with warfarin may enhance the release of atheromatous plaque emboli, thereby increasing the risk of complications from systemic cholesterol microembolization, including the "purple toes syndrome." Systemic atheroemboli and cholesterol microemboli can present with a variety of signs and symptoms. "Purple toes syndrome" is a complication of oral anticoagulation characterized by a dark, purplish or mottled color of the toes, usually occurring between three to 10 weeks, or later, after the initiation of therapy with warfarin or related compounds. Discontinuation of warfarin therapy is recommended when such phenomena are observed. Warfarin should also be used with caution in patients with heparin-induced thrombocytopenia and deep venous thrombosis. The decision to administer warfarin in the following conditions must be based upon clinical judgment in which the risks of anticoagulant therapy are weighed against the benefits: lactation, severe to moderate hepatic or renal insufficiency, infectious diseases or disturbances of intestinal flora, trauma, surgery, indwelling catheters, severe to moderate hypertension and known or suspected deficiency in protein C mediated anticoagulant response, polycythemia vera, vasculitis, and severe diabetes.[3,5,6]

These contraindications/precautions have resulted in the assignment by the Food and Drug Administration of the Black Box Warnings outlined below.

Black Box Warning for rivaroxaban (Xarelto®)[2,5,6]

WARNING
Hematomas: Epidural or spinal hematomas may occur in patients who are anticoagulated and are receiving neuraxial anesthesia or undergoing spinal puncture. These hematomas may result in long term or permanent paralysis. Consider these risks when scheduling patients for spinal procedures. Factors that can increase the risk of developing epidural or spinal hematomas in these patients include the use of indwelling epidural catheters; concomitant use of other drugs that affect hemostasis, such as nonsteroidal anti-inflammatory drugs, platelet inhibitors, other anticoagulants; a history of traumatic or repeated epidural or spinal punctures and a history of spinal deformity or spinal surgery. Neurological impairment: Monitor patients frequently for signs and symptoms of neurological impairment. If neurological compromise is noted, urgent treatment is necessary. Neuraxial intervention: Consider the benefits and risks before neuraxial intervention in patients anticoagulated or to be anticoagulated for thromboprophylaxis.

Black Box Warning for warfarin (Coumadin®, Jantoven®)[3,5,6]

WARNING
Bleeding risk: Warfarin can cause major or fatal bleeding. Bleeding is more likely to occur during the starting period and with a higher dose (resulting in a higher international normalized ratio [INR]). Risk factors for bleeding include high intensity of anticoagulation (International Normalized Ratio [INR] >4), ≥65 years of age, highly variable INRs, history of gastrointestinal bleeding, hypertension, cerebrovascular disease, serious heart disease, anemia, malignancy, trauma, renal function impairment, concomitant drugs and long duration of warfarin therapy. Regular monitoring of INR should be performed on all treated patients. Those at high risk of bleeding may benefit from more frequent INR monitoring, careful dose adjustment to desired INR and a shorter duration of therapy. Patients should be instructed about prevention measures to minimize risk of bleeding and to report immediately to health care provider signs and symptoms of bleeding.

Drug Interactions

Table 10. Drug Interactions[1-3,5,6]

Generic Name	Interacting Medication or Disease	Potential Result
Oral anticoagulants (dabigatran	P-glycoprotein inducers (i.e., rifampin)	The exposure of dabigatran etexilate mesylate and rivaroxaban may be decreased, resulting in decreased

Generic Name	Interacting Medication or Disease	Potential Result
etexilate mesylate, rivaroxaban)		therapeutic effects.
Oral anticoagulants (rivaroxaban, warfarin)	Salicylates	The risk of bleeding may be increased. The adverse reactions of aspirin on gastric mucosa and platelet function also may enhance the possibility of hemorrhage.
Oral anticoagulants (rivaroxaban)	Clopidogrel	The risk of bleeding may be increased, and bleeding time may be increased.
Oral anticoagulants (rivaroxaban)	Dabigatran etexilate mesylate	The risk of bleeding may be increased.
Oral anticoagulants (rivaroxaban)	Heparins	Additive effects on anti-factor Xa activity and the risk of bleeding may be increased.
Oral anticoagulants (rivaroxaban)	Nonsteroidal anti-inflammatory drugs	Nonsteroidal anti-inflammatory drugs are known to increase bleeding, and bleeding risk may be increased when rivaroxaban is given concomitantly.
Oral anticoagulants (rivaroxaban)	P-glycoprotein inhibitors (i.e., clarithromycin)	The exposure of rivaroxaban may be increased, resulting in increased therapeutic effects and risk of bleeding.
Oral anticoagulants (rivaroxaban)	Strong cytochrome P450 3A4 inhibitors (i.e., ketoconazole)	The exposure of rivaroxaban may be increased, resulting in increased therapeutic effects and risk of bleeding.
Oral anticoagulants (rivaroxaban)	Warfarin	The risk of bleeding may be increased.
Oral anticoagulants (warfarin)	Acetaminophen	Acetaminophen appears to increase the antithrombotic effect of warfarin in a dose-dependent manner.
Oral anticoagulants (warfarin)	Alteplase	The risk of serious bleeding may be increased.
Oral anticoagulants (warfarin)	Aminoglutethimide	Warfarin's action to decrease prothrombin levels may be reduced.
Oral anticoagulants (warfarin)	Amiodarone	The hypoprothrombinemic effect of warfarin is augmented.
Oral anticoagulants (warfarin)	Androgens (17-alkyl derivatives)	The hypoprothrombinemic effect of warfarin is potentiated.
Oral anticoagulants (warfarin)	Antineoplastic agents	The anticoagulant effect of warfarin may be increased.
Oral anticoagulants (warfarin)	Argatroban	The risk of bleeding may be increased due to abnormal prolongation of the prothrombin time and International Normalized Ratio.
Oral anticoagulants (warfarin)	Azole antifungals	The anticoagulant effect of warfarin may be increased.
Oral anticoagulants (warfarin)	Barbiturates	The effects of warfarin may be decreased.
Oral anticoagulants (warfarin)	Bosentan	The effects of warfarin may be decreased.
Oral anticoagulants (warfarin)	Carbamazepine	The effects of warfarin may be decreased.
Oral anticoagulants (warfarin)	Cephalosporins	The effects of warfarin may be increased.
Oral anticoagulants (warfarin)	Chloramphenicol	The effects of warfarin may be increased.
Oral anticoagulants	Cholestyramine	The effects of warfarin may be decreased.

Generic Name	Interacting Medication or Disease	Potential Result
(warfarin)		
Oral anticoagulants (warfarin)	Corticosteroids	The anticoagulant dose requirements may be reduced. Corticosteroids may induce hypercoagulation that could oppose warfarin actions.
Oral anticoagulants (warfarin)	Dextrothyroxine	The hypoprothrombinemic effect of warfarin is increased.
Oral anticoagulants (warfarin)	Disulfiram	The effects of warfarin may be increased.
Oral anticoagulants (warfarin)	Ethchlorvynol	The hypoprothrombinemic effect of warfarin is decreased.
Oral anticoagulants (warfarin)	Fibric acids	The hypoprothrombinemic effect of warfarin is increased.
Oral anticoagulants (warfarin)	Gefitinib	The effects of warfarin may be increased.
Oral anticoagulants (warfarin)	Glutethimide	Inadequate therapeutic response to warfarin may occur.
Oral anticoagulants (warfarin)	Griseofulvin	The effects of warfarin may be decreased.
Oral anticoagulants (warfarin)	Histamine H_2 antagonists	The effects of warfarin may be increased.
Oral anticoagulants (warfarin)	Hydroxymethylglutaryl coenzyme A reductase inhibitors	The effects of warfarin may be increased.
Oral anticoagulants (warfarin)	Hydantoins	Hydantoin serum concentrations may be increased, resulting in possible toxicity. Prothrombin time may be increased, increasing the risk of bleeding.
Oral anticoagulants (warfarin)	Macrolides	The anticoagulant effect of warfarin may be increased.
Oral anticoagulants (warfarin)	Metronidazole	The effects of warfarin may be increased.
Oral anticoagulants (warfarin)	Nevirapine	The effects of warfarin may be decreased.
Oral anticoagulants (warfarin)	Penicillins	Large intravenous doses of penicillins can increase the bleeding risks of warfarin by prolonging bleeding time.
Oral anticoagulants (warfarin)	Quinidine derivatives	The effects of warfarin may be increased.
Oral anticoagulants (warfarin)	Quinolones	The effects of warfarin may be increased.
Oral anticoagulants (warfarin)	Rifamycins	The effects of warfarin may be decreased.
Oral anticoagulants (warfarin)	Sulfonamides	The effects of warfarin may be increased.
Oral anticoagulants (warfarin)	Sulfinpyrazone	The effects of warfarin may be increased.
Oral anticoagulants (warfarin)	Tamoxifen	The hypoprothrombinemic effect of warfarin is increased.
Oral anticoagulants (warfarin)	Tetracyclines	The effects of warfarin may be increased.
Oral anticoagulants (warfarin)	Thioamides	The effects of warfarin may be augmented.
Oral anticoagulants	Thiopurines	The effects of warfarin may be decreased.

Generic Name	Interacting Medication or Disease	Potential Result
(warfarin)		
Oral anticoagulants (warfarin)	Thyroid hormones	The effects of warfarin may be increased.
Oral anticoagulants (warfarin)	Tramadol	The effects of warfarin may be increased.
Oral anticoagulants (warfarin)	Trazodone	The hypoprothrombinemic effect of warfarin is decreased.
Oral anticoagulants (warfarin)	Vitamin E	The effects of warfarin may be increased.
Oral anticoagulants (warfarin)	Vitamin K	The effects of warfarin is attenuated or reversed, leading to possible thrombus formation.

Dosing and Administration

When converting patients from warfarin to dabigatran etexilate mesylate or rivaroxaban, warfarin should be discontinued and dabigatran etexilate mesylate or rivaroxaban should be started when the International Normalized Ratio (INR) is <2.0. For patients currently receiving a parenteral anticoagulant, dabigatran etexilate mesylate or rivaroxaban should be started zero to two hours before the time that the next dose of the parenteral medication was to have been administered, or at the time of discontinuation of a continuously administered parenteral medication.[1,2]

Patients receiving dabigatran etexilate mesylate should be instructed to swallow the capsules whole. Breaking, chewing, or emptying the contents of the capsule can result in increased exposure.
If possible, dabigatran etexilate mesylate should be discontinued one to five days before invasive or surgical procedures because of the increased risk of bleeding. A longer time should be considered for patients undergoing major surgery, spinal surgery, or placement of a spinal or epidural catheter or part, in whom complete hemostasis may be required. If surgery cannot be delayed, there is an increased risk of bleeding.[1]

If anticoagulation must be discontinued to reduce the risk of bleeding with surgical or other procedures, rivaroxaban should be stopped at least 24 hours before the procedure. In deciding whether a procedure should be delayed until 24 hours after the last dose of rivaroxaban, the increased risk of bleeding should be weighed against the urgency of intervention. Rivaroxaban should be restarted after the surgical or other procedures as soon as adequate hemostasis has been established. If oral medication cannot be taken after surgical intervention consider administering a parenteral anticoagulant.[2]

The recommended dose of rivaroxaban varies depending on indication. The recommended treatment duration for rivaroxaban is 35 and 12 days, respectively, for patients undergoing hip or knee replacement surgery. Rivaroxaban may be administered independently of meals when used for prophylaxis of deep vein thrombosis. When used in atrial fibrillation, administration with the evening meal is recommended. Drugs that alter the gastric pH have not been shown to have an effect on the absorption of rivaroxaban.[2]

The dosage and administration of warfarin must be individualized for each patient according to the patient's prothrombin time /INR response to the drug, with the dosage adjusted based on this measurement. The best available information supports the dosage and administration recommendations for warfarin that are outlined in Table 11.[3,5,6] The selected starting dose of warfarin should be based on the expected maintenance dose. The initial dose of warfarin is usually 2 to 5 mg/day; however, this dose should be modified based on consideration of patient-specific clinical factors. Lower initial doses should be considered for elderly and/or debilitated patients. Regarding maintenance treatment, most patients are satisfactorily maintained at a dose of 2 to 10 mg/day. Flexibility of dosage is provided by breaking scored tablets in half, and the individual dose and interval should be gauged by the patient's prothrombin response. The duration of therapy in each patient is also individualized. In general, treatment with warfarin should be continued until the danger of thrombosis and embolism has passed.[3,5,6]

Table 11. Dosing and Administration[1-3,5,6]

Generic Name	Usual Adult Dose	Usual Pediatric Dose	Availability
Dabigatran etexilate mesylate	Reduce the risk of stroke and systemic embolism in patients with non-valvular AF: Capsule: 150 mg BID	Safety and efficacy in children have not been established.	Capsule: 75 mg 150 mg
Rivaroxaban	Prophylaxis of DVT, which may lead to PE in patients undergoing knee or hip replacement therapy: Tablet: 10 mg QD Reduce the risk of stroke and systemic embolism in patients with non-valvular AF: Tablet: 15 or 20 mg QD	Safety and efficacy in children have not been established.	Tablet: 10 mg 15 mg 20 mg
Warfarin	Prophylaxis and treatment of the thromboembolic complications associated with AF and/or cardiac valve replacement: Tablet: initial, 2 to 5 mg/day; maintenance, 2 to 10 mg/day; maintain an INR of 2.0 to 3.0 Prophylaxis and treatment of venous thrombosis and its extension, PE: Tablet: initial, 2 to 5 mg/day; maintenance, 2 to 10 mg/day; treat for six to 12 months or indefinitely Reduce the risk of death, recurrent MI and thromboembolic events such as stroke or systemic embolization after MI: Tablet: initial, 2 to 5 mg/day; maintenance, 2 to 10 mg/day; maintain an INR of 3.0 to 4.0 (high intensity) or of 2.0 to 3.0 (moderate intensity)	Safety and efficacy in children have not been established.*	Tablet: 1 mg 2 mg 2.5 mg 3 mg 4 mg 5 mg 6 mg 7.5 mg 10 mg

*The use of warfarin in pediatric patients is well documented for the prevention and treatment of thromboembolic events.
AF=atrial fibrillation, BID=twice-daily, DVT=deep vein thrombosis, INR=International Normalized Ratio, MI=myocardial infarction, PE=pulmonary embolism, QD=once-daily

Clinical Guidelines

Current guidelines are summarized in Table 12. Please note that guidelines addressing thromboprophylaxis are presented globally, addressing the role of various medication classes. Due to the complexity of clinical guidelines for atrial fibrillation and secondary prevention of coronary artery disease (or myocardial infarction), these clinical guideline summaries focus on the role of oral anticoagulants in disease management. The American College of Chest Physicians has not updated their 2008 guidelines on the use of antithrombotic and thrombolytic therapies since the Food and Drug Administration-approval of rivaroxaban. Due to the current lack of guidance on the use of rivaroxaban, the 2010 National Institute for Health and Clinical Excellence and Scottish Intercollegiate Guidelines Network guidelines have been included, which address the role of this agent.[20,21]

While not approved, the use of warfarin is addressed within two guidelines for the management of peripheral artery disease and chronic stable angina. According to the American College of Cardiology,

warfarin is not indicated to reduce the risk of adverse cardiovascular ischemic events in patients with atherosclerotic lower extremity peripheral artery disease. The American College of Cardiology also notes that if warfarin is to be used in combination with aspirin and/or clopidogrel for the treatment of chronic stable angina, patients should be monitored closely due to an increased risk of bleeding.[39,40]

Table 12. Clinical Guidelines

Clinical Guideline	Recommendations
American College of Chest Physicians: **Antithrombotic and Thrombolytic Therapy (8th edition) (Executive Summary, 2008)**[17]	<u>Pharmacology and management of vitamin K antagonists (VKAs)</u> • Initiation and maintenance dosing: o In patients beginning therapy, an initial dose of 5 to 10 mg for the first one or two days is recommended for most individuals. Subsequent dosing should be based on the International Normalized Ratio (INR) response. • Initiation of anticoagulation in the elderly or other populations: o In elderly patients or patients who are debilitated, are malnourished, have congestive heart failure, have liver disease, have recent major surgery, or are taking medications known to increase the sensitivity of warfarin, an initial dose ≤5 mg is recommended. Subsequent dosing should be based on the INR response. • Frequency of monitoring: o In patients beginning therapy, it is suggested that INR monitoring be started after the initial two or three doses of oral anticoagulation therapy. o For patients receiving a stable dose of oral anticoagulants, monitoring is suggested at an interval of no longer than every four weeks. <u>Prevention of venous thromboembolism (VTE)</u> • General recommendations: o It is recommended that renal function be considered when making decisions about the use and/or dose of low molecular weight heparin (LMWH), fondaparinux, and other antithrombotic drugs that are cleared by the kidneys. Depending on the circumstances, it is recommended to avoid the use of an anticoagulant that bioaccumulates in the presence of renal impairment, using a lower dose of the agent or monitoring the drug level or its anticoagulant effect. • Orthopedic surgery-elective hip replacement: o The routine use of one of the following anticoagulant options is recommended: LMWH, fondaparinux, or adjusted-dose VKA. o Use of any of the following as the sole method of thromboprophylaxis is not recommended: aspirin, dextran, low-dose unfractionated heparin (UFH), graduated compression stockings, or venous foot pump. • Orthopedic surgery-elective knee replacement: o Routine thromboprophylaxis using LMWH, fondaparinux, or adjusted-dose VKA is recommended. o The optimal use of intermittent pneumatic compression is an alternative option to anticoagulant thromboprophylaxis. o Use of any of the following as the only method of thromboprophylaxis is not recommended: aspirin, low-dose UFH, or venous foot pump. • Orthopedic surgery-knee arthroscopy:

Clinical Guideline	Recommendations
	○ In patients who do not have additional thromboembolic risk factors, it is suggested that clinicians not routinely use thromboprophylaxis other than early mobilization. ○ In patients who have additional thromboembolic risk factors or who have undergone a complicated surgery, LMWH is recommended for thromboprophylaxis. • Orthopedic surgery-hip fracture surgery: ○ Routine thromboprophylaxis with fondaparinux, LMWH, adjusted-dose VKA, or low-dose UFH is recommended. ○ Use of aspirin alone is not recommended. ○ In patients who will likely have a delayed surgery, thromboprophylaxis with LMWH or low-dose UFH initiated during the time between hospital admission and surgery is recommended. • Other thromboprophylaxis issues in major orthopedic surgery: ○ For patients receiving LMWH, starting therapy either preoperatively or postoperatively is recommended. ○ For patients receiving fondaparinux, starting therapy either six to eight hours after surgery or the next day is recommended. ○ For patients undergoing total hip replacement, total knee replacement, or hip fracture surgery, thromboprophylaxis for at least 10 days is recommended. ○ For patients undergoing total hip replacement, it is recommended that thromboprophylaxis be extended beyond 10 days and up to 35 days after surgery. Recommended options for extended prophylaxis include LMWH, a VKA, or fondaparinux. ○ For patients undergoing total knee replacement, it is suggested that thromboprophylaxis be extended beyond 10 days and up to 35 days after surgery. Recommended options for extended prophylaxis include LMWH, a VKA, or fondaparinux. ○ For patients undergoing hip fracture surgery, it is recommended that thromboprophylaxis be extended beyond 10 days and up to 35 days after surgery. Recommended options for extended prophylaxis include fondaparinux, LMWH, or a VKA. <u>Medical conditions</u> • For acutely ill medical patients admitted to the hospital with congestive heart failure or severe respiratory disease, or who are confined to bed and have one or more additional risk factors, including active cancer, previous VTE, sepsis, acute neurologic disease, or inflammatory bowel disease, thromboprophylaxis with LMWH, low-dose UFH, or fondaparinux is recommended. • For medical patients with risk factors for VTE, and in whom there is a contraindication to anticoagulant thromboprophylaxis, the optimal use of mechanical thromboprophylaxis is recommended. <u>Cancer patients</u> • In patients undergoing surgical procedures, routine thromboprophylaxis that is appropriate for the type of surgery is recommended. • In patients who are bedridden with an acute medical illness, routine thromboprophylaxis as for other high-risk medical patients is recommended. • In patients with indwelling central venous catheters, use of prophylactic

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	doses of LMWH or mini doses of warfarin to prevent catheter-related thrombosis is not recommended. • In patients receiving chemotherapy or hormonal therapy, the routine use of thromboprophylaxis for the primary prevention of VTE is not recommended. • The routine use of primary thromboprophylaxis to try to improve survival is not recommended. <u>Antithrombotic therapy for venous thromboembolic disease</u> • Initial anticoagulation of acute deep vein thrombosis (DVT) of the leg: o For patients with objectively confirmed DVT, short-term treatment with subcutaneous (SC) LMWH, intravenous (IV) unfractionated heparin (UFH), monitored SC UFH, fixed-dose SC UFH, or SC fondaparinux rather than no such acute treatment is recommended. o For patients with a high clinical suspicion of DVT, treatment with anticoagulants while awaiting the outcome of the diagnostic tests is recommended. o In patients with acute DVT, initial treatment with LMWH, UFH, or fondaparinux for at least five days, until the INR is ≥2.0 for 24 hours, is recommended. o In patients with acute DVT, initiation of VKA together with LMWH, UFH, or fondaparinux on the first treatment is recommended. • Duration of anticoagulant therapy: o For patients with DVT secondary to a transient (reversible) risk factor, three months of VKA therapy is recommended over shorter treatment periods. o For patients with unprovoked DVT, at least three months of VKA therapy is recommended. After three months, all patients should be evaluated for the risk-benefit ratio of long-term therapy. For patients with a first unprovoked VTE that is a proximal DVT, and in whom risk factors for bleeding are absent and for whom good anticoagulant monitoring is achievable, long-term treatment is recommended. For patients with a second episode of unprovoked VTE, long-term treatment is recommended. For patients with a first isolated distal DVT that is unprovoked, three months of anticoagulant therapy is sufficient rather than indefinite therapy. o For patients with DVT and cancer, LMWH for the first three to six months of long-term anticoagulant therapy is recommended. For these patients, subsequent therapy with VKA or LMWH indefinitely or until the cancer is resolved is recommended. o In patients who receive long-term anticoagulant treatment, the risk-benefit ratio of continuing such treatment should be reassessed periodically. • Intensity of anticoagulant effect: o In patients with DVT, it is recommended that the dose of VKA be adjusted to maintain a target INR of 2.5 (range, 2.0 to 3.0) for all treatment durations. o For patients with unprovoked DVT who have a strong preference for less frequent INR testing, after the first three months of conventional intensity anticoagulation, low intensity therapy (INR range, 1.5 to 1.9) with less frequent monitoring over stopping therapy is suggested.

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	o High intensity VKA therapy (INR range, 3.1 to 4.0) compared to an INR range of 2.0 to 3.0 is not recommended. • Treatment of asymptomatic DVT of the leg: o In patients who are unexpectedly found to have asymptomatic DVT, the same initial and long-term anticoagulation as for comparable patients with symptomatic DVT is recommended. • IV or SC UFH, SC LMWH, SC fondaparinux, and VKA for the initial treatment of pulmonary embolism (PE): o For patients with objectively confirmed PE, short-term treatment with SC LMWH, IV UFH, monitored SC UFH, fixed-dose SC UFH, or SC fondaparinux rather than no such acute treatment is recommended. Patients with acute PE should also be routinely assessed for treatment with thrombolytic therapy. o For patients in whom there is a high clinical suspicion of PE, treatment with anticoagulants while awaiting the outcome of diagnostic tests is recommended. o In patients with acute PE, initial treatment with LMWH, UFH, or fondaparinux for at least five days and until the INR is ≥2.0 for at least 24 hours is recommended. o In patients with acute PE, initiation of VKA together with LMWH, UFH, or fondaparinux on the first day of treatment is recommended. o In patients with acute nonmassive PE, initial treatment with LMWH over IV UFH is recommended. In patients with massive PE, in other situations where there is concern about SC absorption or in patients in whom thrombolytic therapy is being considered or planned, IV UFH over SC LMWH, SC fondaparinux, or SC UFH is suggested. o In patients with acute PE treated with LMWH, routine monitoring with anti-factor Xa level measurements is not recommended. o In patients with acute PE and severe renal failure, UFH over LMWH is suggested. <u>Long-term treatment of acute PE</u> • For patients with secondary PE to a transient risk factor, three months of VKA therapy over shorter treatment periods is recommended. • For patients with unprovoked PE, at least three months of VKA therapy is recommended. After three months, all patients should be evaluated for the risk-benefit ratio of long-term therapy. For patients with a first unprovoked VTE that is a PE, and in whom risk factors for bleeding are absent and for whom good anticoagulant monitoring is achievable, long-term treatment is recommended. For patients with a second episode of unprovoked VTE, long-term treatment is recommended. • For patients with PE and cancer, LMWH for the first three to six months of long-term anticoagulant therapy is recommended. For these patients, subsequent therapy with VKA or LMWH indefinitely or until the cancer is resolved is recommended. • In patients who receive long-term anticoagulant treatment, the risk-benefit ratio of continuing such treatment should be reassessed periodically. • In patients with PE, it is recommended that the dose of VKA be adjusted to maintain a target INR of 2.5 (range, 2.0 to 3.0) for all treatment durations. • For patients with unprovoked PE who have a strong preference for less frequent INR testing, after the first three months of conventional-intensity

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	anticoagulation, low intensity therapy (INR range, 1.5 to 1.9) with less frequent monitoring over stopping therapy is suggested. • High intensity VKA therapy (INR range, 3.1 to 4.0) compared to an INR range of 2.0 to 3.0 is not recommended. • In patients who are unexpectedly found to have asymptomatic PE, the same initial and long-term anticoagulation as for comparable patients with symptomatic PE is recommended. <u>Antithrombotic therapy in atrial fibrillation (AF)</u> • AF: o In patients with AF, including those with paroxysmal AF, who have had a prior ischemic stroke, transient ischemic attack (TIA), or systemic embolism, long-term anticoagulation with an oral VKA, such as warfarin, is recommended. The target INR should be 2.5 (range, 2.0 to 3.0) because of the high risk of future ischemic stroke in these patients. Timing of initiation of therapy after an acute ischemic stroke involves balancing risks of hemorrhagic conversion with short-term risk of recurrent ischemic stroke. o In patients with AF, including those with paroxysmal AF, who have two or more risk factors for future ischemic stroke, long-term anticoagulation with an oral VKA, such as warfarin, is recommended. The target INR should be 2.5 (range, 2.0 to 3.0) because of the high risk of future ischemic stroke in these patients. Risk factors include age >75 years, history of hypertension, diabetes, and moderately or severely impaired left ventricular systolic function and/or heart failure. o In patients with AF, including those with paroxysmal AF, with only one risk factor (age >75 years, history of hypertension, diabetes, and moderately or severely impaired left ventricular systolic function and/or heart failure), long-term antithrombotic therapy, either as anticoagulation with an oral VKA, such as warfarin, or as aspirin (75 to 325 mg/day) is recommended. The target INR should be 2.5 (range, 2.0 to 3.0). For patients at intermediate risk of ischemic stroke, a VKA is suggested over aspirin. o In patients with AF, including those with paroxysmal AF, aged ≤75 years and with none of the other risk factors, long-term aspirin therapy (75 to 325 mg/day) is recommended because of their low risk of ischemic stroke. • Valvular heart disease and AF: o For patients with AF and mitral stenosis, long-term anticoagulation with an oral VKA, such as warfarin, is recommended. The target INR should be 2.5 (range, 2.0 to 3.0). o For patients with AF and prosthetic heart valves long-term anticoagulation with an oral VKA, such as warfarin, at an intensity appropriate for the specific type of prosthesis is recommended. <u>The primary and secondary prevention of chronic coronary artery disease</u> • For most patients after myocardial infarction (MI), in health-care settings in which meticulous INR monitoring and highly skilled VKA dose titration are expected and widely accessible, long-term (up to four years) high intensity oral VKA (target INR, 3.5; range, 3.0 to 4.0) without concomitant aspirin or moderate intensity oral VKA (target, 2.5; range, 2.0 to 3.0) with aspirin over aspirin alone is suggested.

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	• For high-risk MI patients, combined use of moderate intensity VKA plus low dose aspirin for at least three months after the MI is suggested. • VKA is not recommended for patients undergoing percutaneous coronary intervention (PCI) with no other indication for VKA. • In patients with congestive heart failure due to a nonischemic etiology, the routine use of aspirin or oral VKA is not recommended. • VKAs are not recommended in patients undergoing coronary artery bypass grafting surgery who have no other indication for a VKA. For patients in whom anticoagulant therapy is indicated, VKA plus aspirin is suggested. • VKAs are not recommended for patients undergoing internal mammary artery bypass grafting who have no other indication for a VKA. • For patients at particularly high risk of events in whom INR can be monitored without difficulty, low dose VKA (target, 1.5) over aspirin is suggested.
American College of Cardiology Foundation/ American Heart Association/Heart Rhythm Society: **Focused Update on the Management of Patients with Atrial Fibrillation (Updating the 2006 Guideline[8]) (2011)**[7]	• With the exception of the recommendations presented in this Focused Update, the full-text guideline remains current. The 2006 guidelines are outlined below.[8] <u>Recommendations for combining anticoagulant with antiplatelet therapy</u> • Multiple trials have demonstrated that oral anticoagulation with warfarin is effective for the prevention of thromboembolism in AF patients. • Aspirin only offers modest protection against stroke in AF patients. • Adjusted-dose oral anticoagulation is more efficacious than aspirin for prevention of stroke in patients with AF. • The addition of clopidogrel to aspirin to reduce the risk of major vascular events, including stroke, might be considered in patients with AF in whom oral anticoagulation with warfarin is considered unsuitable due to patient preference or the physician's assessment of the patient's ability to safely sustain anticoagulation.
American College of Cardiology Foundation/ American Heart Association/Heart Rhythm Society: **Focused Update on the Management of Patients with Atrial Fibrillation (Update on Dabigatran) (2011)**[18]	<u>Recommendations for emerging antithrombotic agents</u> • Dabigatran is useful as an alternative to warfarin for the prevention of stroke and systemic thromboembolism in patients with paroxysmal to permanent AF and risk factors for stroke or systemic embolization who do not have a prosthetic heart valve or hemodynamically significant valve disease, severe renal failure (creatinine clearance <15 mL/minute), or advanced liver disease. • Because of the twice-daily dosing and greater risk of nonhemorrhagic side effects with dabigatran, patients already taking warfarin with excellent INR control may have little to no gain by switching to dabigatran. • Selection of patients with AF, who have at least one additional risk factor for stroke, who could benefit from dabigatran over warfarin should consider individual clinical features including the ability to comply with twice-daily dosing, availability of an anticoagulation management program to sustain routine monitoring of INR, patient preferences, cost, and other factors.
American College of Cardiology/ American Heart Association/ European Society of Cardiology: **Guidelines for the Management of**	<u>Preventing thromboembolism</u> • Antithrombotic therapy to prevent thromboembolism is recommended for all patients with AF, except those with lone AF or contraindications. • Selection of antithrombotic therapy should be based upon absolute risks of stroke and bleeding and the relative risk and benefit for a given patient. • For patients without mechanical heart valves at high risk of stroke, chronic oral anticoagulation therapy with a VKA is recommended in a dose

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Patients with Atrial Fibrillation (Executive Summary, 2006)[8]	adjusted to achieve a target intensity INR of 2.0 to 3.0, unless contraindicated. Factors associated with highest risk for stroke in patients with AF are prior thromboembolism (e.g., stroke, TIA, systemic embolism) and rheumatic mitral stenosis. • Anticoagulation with a VKA is recommended for patients with more than one moderate risk factor. Such factors include age ≥75, hypertension, heart failure, impaired left ventricular systolic function (ejection fraction ≤35% or fractional shortening <25%), and diabetes. • INR should be determined at least weekly during initiation of therapy and monthly when anticoagulation is stable. • Aspirin (81 to 325 mg/day) is recommended as an alternative to VKA in low-risk patients or in those with contraindications to oral anticoagulation. • For patients with AF who have mechanical heart valves, the target intensity of anticoagulation should be based on the type of prosthesis, maintaining an INR of ≥2.5. • Antithrombotic therapy is recommended for patients with atrial flutter as for those with AF. • For primary prevention of thromboembolism in patients with nonvalvular AF who have just one validated risk factor (age ≥75 years [especially in female patients], hypertension, heart failure, impaired left ventricular function, diabetes) antithrombotic therapy with either aspirin or a VKA is reasonable, based upon an assessment of the risk of bleeding complications, ability to safely sustain adjusted chronic anticoagulation and patient preferences. • For patients with nonvalvular AF who have one or more of the less well validated risk factors (age 65 to 74 years, female gender, coronary artery disease), antithrombotic therapy with either aspirin or a VKA is reasonable for prevention of thromboembolism. The choice of agent should be based upon the risk of bleeding complications, ability to safely sustain adjusted chronic anticoagulation, and patient preferences. • It is reasonable to select antithrombotic therapy using the same criteria irrespective of the pattern (i.e., paroxysmal, persistent, permanent) of AF. • In patients with AF who do not have mechanical prosthetic heart valves, it is reasonable to interrupt anticoagulation for up to one week without substituting heparin for surgical or diagnostic procedures that carry a risk of bleeding. • It is reasonable to re-evaluate the need for anticoagulation at regular intervals. • In patients ≥75 years at increased risk of bleeding but without frank contraindications to oral anticoagulant therapy, and in other patients with moderate risk factors for thromboembolism who are unable to safely tolerate anticoagulation at the standard intensity of INR 2.0 to 3.0, a lower INR target of 2.0 (range, 1.6 to 2.5) may be considered for primary prevention of ischemic stroke and systemic embolism. • When surgical procedures require interruption of oral anticoagulant therapy for longer than one week in high-risk patients, UFH may be administered or LMWH given by SC injection, although the efficacy of these alternatives in this situation is uncertain. • Following PCI or revascularization surgery in patients with AF, low-dose aspirin (<100 mg/day) and/or clopidogrel (75 mg/day) may be given concurrently with anticoagulation to prevent myocardial ischemic events. These strategies have not been thoroughly evaluated and are associated with an increased risk of bleeding.

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	• In patients undergoing PCI, anticoagulation may be interrupted to prevent bleeding at the site of peripheral arterial puncture, but the VKA should be resumed as soon as possible after the procedure and the dose adjusted to achieve an INR in the therapeutic range. Aspirin may be given temporarily during the hiatus, but the maintenance regimen should then consist of the combination of clopidogrel (75 mg/day) plus warfarin (INR, 2.0 to 3.0). Clopidogrel should be given for a minimum of one month after implantation for a bare metal stent, at least three months for a sirolimus-eluting stent, at least six months for paclitaxel-eluting stent, and 12 months or longer in selected patients, following which warfarin may be continued as monotherapy in the absence of a subsequent coronary event. When warfarin is given in combination with clopidogrel or low dose aspirin, the dose intensity must be carefully regulated. • In patients with AF <60 years without heart disease or risk factors for thromboembolism (lone AF), the risk of thromboembolism is low without treatment and the effectiveness of aspirin for primary prevention of stroke relative to the risk of bleeding has not been established. • In patients with AF who sustain ischemic stroke or systemic embolism during treatment with low intensity anticoagulation (INR, 2.0 to 3.0), rather than add an antiplatelet agent, it may be reasonable to raise the intensity of the anticoagulation to a maximum target INR of 3.0 to 3.5. • Long-term anticoagulation with a VKA is not recommended for primary prevention of stroke in patients <60 years without heart disease (lone AF) or any risk factors for thromboembolism.
The American Heart Association: **Management of Massive and Submassive Pulmonary Embolism, Iliofemoral Deep Vein Thrombosis, and Chronic Thromboembolic Pulmonary Hypertension: A Scientific Statement From the American Heart Association (2011)**[41]	<u>Recommendations for initial anticoagulation for acute PE</u> • Therapeutic anticoagulation with SC LMWH, IV or SC UFH with monitoring, unmonitored weight-based SC UFH, or SC fondaparinux should be given to patients with objectively confirmed PE and no contraindications to anticoagulation. • Therapeutic anticoagulation during the diagnostic workup should be given to patients with intermediate or high clinical probability of PE and no contraindications to anticoagulation. Fibrinolysis is not recommended for undifferentiated cardiac arrest. <u>Recommendations for initial anticoagulation for patients with iliofemoral DVT</u> • In the absence of suspected or proven heparin induced thrombocytopenia, patients with iliofemoral DVT should receive therapeutic anticoagulation with either IV UFH, SC UFH, a LMWH agent, or fondaparinux. • Patients with iliofemoral DVT who have suspected or proven heparin-induced thrombocytopenia should receive a direct thrombin inhibitor. <u>Recommendations for long-term anticoagulation therapy for patients with iliofemoral DVT</u> • Adult patients with iliofemoral DVT who receive oral warfarin as first-line long-term anticoagulation therapy should have warfarin overlapped with initial anticoagulation therapy for a minimum of five days and until the INR is >2.0 for at least 24 hours, and then targeted to an INR of 2.0 to 3.0. • Patients with first episode iliofemoral DVT related to a major reversible risk factor should have anticoagulation stopped after three months. • Patients with recurrent or unprovoked iliofemoral DVT should have at least six months of anticoagulation and be considered for indefinite anticoagulation with periodic reassessment of the risks and benefits of continued anticoagulation.

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	• Cancer patients with iliofemoral DVT should receive LMWH monotherapy for at least three to six months, or as long as the cancer or its treatment (e.g., chemotherapy) is ongoing. • In children with DVT, the use of LMWH monotherapy may be reasonable.
National Institute for Health and Clinical Excellence: **Venous Thromboembolism: Reducing the Risk (Reducing the Risk of Venous Thromboembolism [Deep Vein Thrombosis and Pulmonary Embolism] in Patients Admitted to the Hospital) (2010)**[20]	<u>Assessing the risks of VTE and bleeding</u> • Assess all patients on admission to identify those who are at increased risk of VTE. Patients at high risk have had or are expected to have significantly reduced mobility for three or more days, or are expected to have ongoing reduced mobility relative to their normal state and have one or more of the following risk factors: active cancer or cancer treatment, age >60 years, critical care admission, dehydration, known thrombophilias, obesity, one or more significant comorbidities, personal history of first degree relative with a history of VTE, use of hormone replacement therapy, use of estrogen-containing contraceptive therapy, or varicose veins with phlebitis. • Regard surgical patients and patients with trauma as being at increased risk of VTE if they meet one of the following criteria: surgical procedure with a total anesthetic and surgical time >90 minutes, or 60 minutes if the surgery involves the pelvis or lower limb; acute surgical admission with inflammatory or intra-abdominal condition; expected significant reduction in mobility; or one or more of the risk factors listed above. • Assess all patients for risk of bleeding before offering pharmacological VTE prophylaxis. Prophylaxis should not be offered to patients with any of the following risk factors for bleeding, unless the risk of VTE outweighs the risk of bleeding: active bleeding, acquired bleeding disorders, concurrent use of anticoagulants known to increase the risk of bleeding, lumbar puncture/epidural/spinal anesthesia expected within the next 12 hours, lumbar puncture/epidural/spinal anesthesia within the previous four hours, acute stroke, thrombocytopenia, uncontrolled systolic hypertension, or untreated inherited bleeding disorders. • Reassess patients' risks of bleeding and VTE within 24 hours of admission and whenever the clinical situation changes. <u>Reducing the risk of VTE</u> • Do not allow patients to become dehydrated unless clinically indicated. • Encourage patients to mobilize as soon as possible. • Do not regard aspirin or other antiplatelet agents as adequate prophylaxis for VTE. • Consider offering temporary inferior vena caval filters to patients who are at very high risk of VTE and for whom mechanical and pharmacological VTE prophylaxis are contraindicated. <u>Reducing the risk of VTE-general medical patients</u> • Offer pharmacological VTE prophylaxis with fondaparinux, LMWH, or UFH to patients assessed to be at an increased risk of VTE. Starts as soon as possible after risk assessments has been completed and continue until the patient is not an increased risk of VTE. <u>Reducing the risk of VTE-patients with stroke</u> • Anti-embolism stockings should not be offered. • Consider offering prophylactic-dose LMWH (or UFH for patients with renal failure) if a diagnosis of hemorrhagic stroke has been excluded, the risk of bleeding is assessed to be low, and the patient has one or more of the

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	following: major restriction of mobility, previous history of VTE, dehydration, or comorbidities. Continue until the acute event is over and the patient's condition is stable. • Until the patient can have pharmacological VTE prophylaxis, consider offering a foot impulse or intermittent pneumatic compression device. <u>Reducing the risk of VTE-patients with cancer</u> • Offer pharmacological VTE prophylaxis with fondaparinux, LMWH, or UFH to patients who are assessed to be at an increased risk of VTE. Start as soon as possible after risk assessment is complete and continue until the patient is no longer at increased risk of VTE. • Do not routinely offer pharmacological or mechanical VTE prophylaxis to patients with cancer having oncological treatment who are ambulant. <u>Reducing the risk of VTE-patients with central venous catheters</u> • Do not routinely offer pharmacological or mechanical VTE prophylaxis to patients who are ambulant; consider prophylaxis in patients who are at an increased risk. <u>Reducing the risk of VTE-patients in palliative care</u> • Consider offering pharmacological VTE prophylaxis with fondaparinux, LMWH, or UFH to patients who have potentially reversible acute pathology. • Do not routinely offer pharmacological or mechanical VTE prophylaxis to patients admitted for terminal care or those commenced on an end of life care pathway. <u>Reducing the risk of VTE-surgical patients</u> • For cardiac surgery, add pharmacological VTE prophylaxis with LMWH or UFH to mechanical prophylaxis in patients who have a low risk of major bleeding, taking into account individual patient factors and according to clinical judgment. Continue until the patient no longer has significantly reduced mobility (generally five to seven days). • For gastrointestinal, gynecological, thoracic, or urological surgeries, add pharmacological VTE prophylaxis with fondaparinux (bariatric and gastrointestinal surgery only), LWMH, or UFH to mechanical prophylaxis in patients who have a low risk of major bleeding, taking into account individual patient factors and according to clinical judgment. Continue until the patient no longer has significantly reduced mobility (generally five to seven days). • Extend pharmacological VTE prophylaxis to 28 days postoperatively for patients who have had major cancer surgery in the abdomen or pelvis. • Do not offer pharmacological VTE prophylaxis to patients with ruptured cranial or spinal vascular malformations or acute traumatic or nontraumatic hemorrhage, until the lesion has been secured or the condition is stable. • For elective hip replacement surgery, offer combined VTE prophylaxis with mechanical and pharmacological methods. Unless contraindicated, start pharmacological VTE prophylaxis after surgery with any of the following: dabigatran, fondaparinux, LMWH, rivaroxaban, or UFH. Continue for 28 to 35 days, according to the summary of product characteristics for the individual agent being used. • For elective knee replacement surgery, offer combined VTE prophylaxis with mechanical and pharmacological methods. Unless contraindicated,

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	start pharmacological VTE prophylaxis after surgery with any of the following: dabigatran, fondaparinux, LMWH, rivaroxaban, or UFH. Continue for 10 to 14 days, according to the summary of product characteristics for the individual agent being used. • For hip fracture surgery, offer combined VTE prophylaxis with mechanical and pharmacological methods. Unless contraindicated, add pharmacological VTE prophylaxis with any of the following: fondaparinux, LMWH, or UFH. Continue for 28 to 35 days, according to the summary of product characteristics for the individual agent being used. • For other orthopedic surgeries, consider offering combined VTE prophylaxis with mechanical and pharmacological methods. Start pharmacological VTE prophylaxis six to 12 hours after surgery with any of the following: LMWH or UFH. Continue until the patient no longer has significantly reduced mobility. • For vascular surgeries, offer VTE prophylaxis to patients who are not having other anticoagulant therapy and are assessed to be at increased risk of VTE. Add pharmacological VTE prophylaxis to mechanical prophylaxis for patients who have a low risk of major bleeding with any of the following: LMWH or UFH. Continue until the patient no longer has significantly reduced mobility (generally five to seven days). • For day surgeries, offer VTE prophylaxis to patients who are assessed to be at increased risk of VTE. Add pharmacological VTE prophylaxis to mechanical prophylaxis for patients who have a low risk of major bleeding with any of the following: fondaparinux, LMWH, and UFH. If significantly reduced mobility is expected after discharge, continue for five to seven days, generally. • For other surgical patients, offer VTE prophylaxis to patients who are assessed to be at increased risk of VTE. Add pharmacological prophylaxis to mechanical prophylaxis for patients who have a low risk of major bleeding with any of the following: LMWH or UFH. Continue until the patient no longer has significantly reduced mobility, generally five to seven days. <u>Reducing the risk of VTE-other patient groups</u> • For major trauma or spinal injury, offer combined VTE prophylaxis with mechanical and pharmacological methods. If the benefits of reducing the risk of VTE outweigh the risks of bleeding and bleeding risk has been established as low, add pharmacological VTE prophylaxis to mechanical prophylaxis with any of the following: LMWH or UFH. Continue pharmacological VTE prophylaxis until the patient no longer has significantly reduced mobility. • For lower limb plaster casts, consider offering pharmacological VTE prophylaxis after evaluating the risks and benefits based on clinical discussion with the patient. Offer LMWH (or UFH for patients with renal failure) until lower limb plaster cast removal. • For pregnancy and up to six weeks post partum, consider offering pharmacological VTE prophylaxis with LMWH (or UFH for patients with renal failure) if the patient has one or more of the following risk factors: expected to have significantly reduced mobility for three or more days, active cancer or cancer treatment, age >35 years, critical care admission, dehydration, excess blood loss or blood transfusion, known thrombophilias, obesity, or one or more significant medical comorbidities: personal history of first degree relative with a history of VTE, pregnancy-

Clinical Guideline	Recommendations
	related risk factor, or varicose veins with phlebitis. • For critical care patients, assess for the risks of VTE and bleeding. Offer pharmacological VTE prophylaxis if the risk of VTE outweighs the risk of bleeding.
Scottish Intercollegiate Guidelines Network: **Prevention and Management of Venous Thromboembolism (2010)**[21]	<u>Thromboprophylaxis in surgical patients</u> • General surgery: o Patients undergoing abdominal surgery who are at risk due to the procedure or personal risk factors should receive thromboprophylaxis with mechanical methods unless contraindicated and either SC LWMH, UFH, or fondaparinux. • Orthopedic surgery: o Patients undergoing total hip replacement or total knee replacement surgery should receive pharmacological prophylaxis (with LMWH, fondaparinux, rivaroxaban, or dabigatran) combined with mechanical prophylaxis unless contraindicated. o Extended prophylaxis should be given. <u>Thromboprophylaxis in medical patients</u> • Pharmacological prophylaxis to prevent asymptomatic and symptomatic VTE: o When the assessment of risk favors use of thromboprophylaxis, UFH, LWMH, or fondaparinux should be administered. • Other medical patients: o Patients with cancer are generally at high risk of VTE and should be considered for prophylaxis with LMWH, UFH, or fondaparinux while hospitalized. <u>Pregnancy and the puerperium</u> • Antenatal thrombosis risk assessment: o All women should be assessed for risk factors for VTE when booking for antenatal care and at each subsequent maternity contact. <u>Further management of VTE</u> • Choice of anticoagulant: o LMWH rather than warfarin should be considered in VTE associated with cancer. • Duration of anticoagulation in lower limb DVT and PE: o After a first episode of proximal limb DVT or PE, treatment with a VKA should be continued for at least three months. <u>Adverse effects of VTE prophylaxis and treatment</u> • Heparin induced thrombocytopenia: o Monitoring patients for the development of heparin induced thrombocytopenia should be by performing serial platelet counts. o Patients who have previously received UFH or LMWH within 100 days or in whom the history of recent exposure to heparins is not clear should have a platelet count performed within 24 hours of receiving the first dose of treatment. • All other patients for whom monitoring is indicated should have platelet counts performed every two to three days from day four to 14 of exposure.
American College of	<u>Secondary prevention following a ST-elevation MI (STEMI)-warfarin therapy:</u>

Clinical Guideline	Recommendations
Cardiology/American Heart Association and American College of Cardiology/American Heart Association/ Society for Cardiovascular Angiography and Interventions: **2009 Focused Update of the 2007 Focused Update and the 2004 Guidelines for the Management of Patients with ST-Segment Elevation Myocardial Infarction AND Guidelines on Percutaneous Coronary Intervention (Updating the 2005 Guideline and 2007 Focused Update) (2009)**[19,22]	• Warfarin should be given to aspirin-allergic post-STEMI patients with indications for anticoagulation as follows: o Without stent implanted (INR, 2.5 to 3.5). o With stent implanted and clopidogrel 75 mg/day administered concurrently (INR, 2.0 to 3.0). • Warfarin (INR, 2.5 to 3.5) is a useful alternative to clopidogrel in aspirin-allergic patients after STEMI who do not have a stent implanted. • Warfarin (INR, 2.0 to 3.0) should be prescribed for post-STEMI patients with either persistent or paroxysmal AF. • In post-STEMI patients with left ventricular thrombus noted on an imaging study, warfarin should be administered for at least three months and indefinitely in patients without an increased risk of bleeding. • Warfarin alone (INR, 2.5 to 3.5) or in combination with aspirin (75 to 162 mg/day) should be administered in post-STEMI patients who have no stent implanted and who have indications for anticoagulation. • In post-STEMI patients <75 years of age without specific indications for anticoagulation who can have their level of anticoagulation monitored reliably, warfarin alone (INR, 2.5 to 3.5) or in combination with aspirin (75 to 162 mg/day) can be useful for secondary prevention. • It is reasonable to administer warfarin in post-STEMI patients with left ventricular dysfunction and extensive regional wall-motion abnormalities. • Warfarin may be considered in patients with severe left ventricular dysfunction, with or without congestive heart failure. • The indications for long-term anticoagulation after STEMI that are presented above remain controversial and are evolving. The "superior" safety, efficacy, and cost-effectiveness of aspirin have made it the antithrombotic agent of choice for secondary prevention.
American College of Cardiology/American Heart Association: **2011 Focused Update of the Guidelines for the Management of Patients with Unstable Angina/ Non-ST-Elevation Myocardial Infarction (Updating the 2007 Guideline) (2011)**[42]	Long-term medical therapy and secondary prevention-warfarin therapy • Use of warfarin in conjunction with aspirin and/or a thienopyridine agent is associated with an increased risk of bleeding, and patients and clinicians should watch for bleeding, especially gastrointestinal, and seek medical evaluation for evidence of bleeding. • Warfarin either without or with low-dose aspirin (75 to 81 mg/day; INR, 2.0 to 2.5) may be reasonable for patients at high coronary artery disease risk and low bleeding risk who do not require or are intolerant of clopidogrel.
European Society of Cardiology: **Guidelines for the Management of Acute Coronary Syndromes in Patients Presenting without Persistent ST-Segment Elevation (2011)**[43]	• These guidelines provide no formal recommendations for the use of oral anticoagulants.
National Institute for	Drugs therapy after an MI-VKAs

Clinical Guideline	Recommendations
Health and Clinical Excellence: **Myocardial Infarction: Secondary Prevention in Primary and Secondary Care for Patients Following a Myocardial Infarction (2007)**[44]	• High intensity warfarin (INR, >3.0) should not be considered as an alternative to aspirin in first-line treatment. • Patients who are unable to tolerate either aspirin or clopidogrel, treatment with moderate intensity warfarin (range, 2.0 to 3.0) should be considered for at least four years. • Patients who are intolerant to clopidogrel and have a low risk of bleeding, treatment with aspirin and moderate intensity warfarin should be considered. • For patients already being treated for another indication, warfarin should be continued. For patients treated with moderate intensity warfarin and who are at low risk of bleeding, the addition of aspirin should be considered. • The combination of warfarin and clopidogrel is not routinely recommended.
American College of Cardiology/American Heart Association: **2007 Chronic Angina Focused Update of the 2002 Guidelines for the Management of Patients With Chronic Stable Angina (2007)**[39]	• Aspirin should be started at 75 to 162 mg/day and continued indefinitely in all patients unless contraindicated. • The use of warfarin in conjunction with aspirin and/or clopidogrel is associated with an increased risk of bleeding and should be monitored closely.
American College of Cardiology/American Heart Association: **American College of Cardiology/ American Heart Association 2005 Guidelines for the Management of Patients With Peripheral Arterial Disease (2005)**[40]	<u>Antiplatelet and antithrombotic drugs</u> • Antiplatelet therapy is indicated to reduce the risk of MI, stroke, or vascular death in individuals with atherosclerotic lower extremity peripheral artery disease. • Aspirin (75 to 325 mg/day) is recommended as safe and effective antiplatelet therapy. • Clopidogrel (75 mg/day) is recommended as an effective alternative antiplatelet therapy. • Warfarin is not indicated to reduce the risk of adverse cardiovascular ischemic events in individuals with atherosclerotic lower extremity peripheral artery disease.
American Heart Association/American Stroke Association: **Guidelines for the Prevention of Stroke in Patients with Stroke or Transient Ischemic Attack (2011)**[45]	<u>Recommendations for patients with cardioembolic stroke types</u> • AF: o For patients with ischemic stroke or TIA with paroxysmal or permanent AF, anticoagulation with a VKA (target INR, 2.0 to 3.0) is recommended. o For patients unable to take oral anticoagulants, aspirin alone is recommended. o The combination of clopidogrel plus aspirin carries a risk of bleeding similar to that of warfarin and therefore is not recommended for patients with a hemorrhagic contraindication to warfarin. o For patients with AF at high risk for stroke who require temporary interruption of oral anticoagulation, bridging therapy with a LMWH agent administered SC is reasonable. • Acute MI and left ventricular thrombus: o Patients with ischemic stroke or TIA in the setting of an acute MI complicated by left ventricular mural thrombus formation should be

Clinical Guideline	Recommendations
	treated with oral anticoagulation (target INR, 2.5; range, 2.0 to 3.0) for at least three months. • Cardiomyopathy: o In patients with prior stroke or transient cerebral ischemic attack in sinus rhythm who have cardiomyopathy characterized by systolic dysfunction, the benefit of warfarin has not been established. o Warfarin (INR, 2.0 to 3.0), aspirin (81 mg/day), clopidogrel (75 mg/day), or the combination of aspirin (25 mg twice-daily) plus extended-release dipyridamole (200 mg twice-daily) may be considered to prevent recurrent ischemic events in patients with pervious ischemic stroke or TIA and cardiomyopathy. • Native valvular heart disease: o For patients with ischemic stroke or TIA who have rheumatic mitral valve disease, whether or not AF is present, long-term warfarin therapy is reasonable with an INR target range of 2.5 (range, 2.0 to 3.0). o To avoid additional bleeding risk, antiplatelet agents should not be routinely added to warfarin. o For patients with ischemic stroke or TIA and native aortic or nonrheumatic mitral valve disease who do not have AF, antiplatelet therapy may be reasonable. o For patients with ischemic stroke or TIA and mitral annular calcification, antiplatelet therapy may be considered. o For patients with mitral valve prolapse who have ischemic stroke or TIA, long-term antiplatelet therapy may be considered. • Prosthetic heart valves: o For patients with ischemic stroke or TIA who have mechanical prosthetic heart valves, warfarin is recommended with a target INR of 3.0 (range, 2.5 to 3.5). o For patients with prosthetic heart valves who have an ischemic stroke or systemic embolism despite adequate therapy with oral anticoagulants, aspirin 75 to 100 mg/day in addition to oral anticoagulants and maintenance of the INR at a target of 3.0 (range, 2.5 to 3.5) is reasonable if the patient is not at high risk of bleeding. o For patients with ischemic stroke or TIA who have bloprosthetic heart valves with no other source of thromboembolism, anticoagulation with warfarin (INR, 2.0 to 3.0) may be considered.

Conclusions

The oral anticoagulants consist of dabigatran etexilate mesylate (Pradaxa®), rivaroxaban (Xarelto®), and warfarin (Coumadin®, Jantoven®). Dabigatran etexilate mesylate and rivaroxaban are Food and Drug Administration (FDA)-approved to reduce the risk of stroke and systemic embolism in patients with non-valvular atrial fibrillation (AF).[1,2] Rivaroxaban is also approved for the prophylaxis of deep vein thrombosis (DVT), which may lead to pulmonary embolism (PE) in patients undergoing knee or hip replacement surgery.[2] Warfarin has various indications, including prophylaxis and/or treatment of PE; prophylaxis and/or treatment of thromboembolic complications associated with AF and/or cardiac valve replacement prophylaxis and/or treatment of venous thrombosis and its extension; and reduce the risk of death, recurrent myocardial infarction (MI) and thromboembolic events such as stroke or systemic embolization after MI.[3] Warfarin, along with aspirin, has been the principle oral anticoagulant for the past 60 years in high-risk AF patients.[4] Warfarin is a generically available vitamin K antagonist, and the evidence from clinical trials and recommendations from current clinical guidelines support the use of warfarin in FDA-approved indications.[8,9,17-19,22,25-34,41] Warfarin and rivaroxaban are approved for once-daily dosing, while

dabigatran etexilate mesylate is administered twice-daily. Both dabigatran etexilate mesylate and rivaroxaban require a dose adjustment in patients with renal impairment and are only available as branded products.[1-6]

Dabigatran etexilate mesylate and rivaroxaban have different mechanisms of action, and affect different parts of the clotting cascade.[1,2] Dabigatran etexilate mesylate is a direct thrombin inhibitor that prevents conversion of fibrinogen into fibrin, while rivaroxaban selectively blocks the active site of factor Xa, preventing the production of thrombin and ultimately preventing platelet activation and the formation of fibrin clots.[1,2] The major advancement with both agents is that they do not require the same monitoring required with warfarin therapy; however, this may make it difficult for physicians to objectively assess adherence to therapy. Dabigatran etexilate mesylate and rivaroxaban are also not associated with the same food and drug interactions that are associated with warfarin. In a head-to-head trial with warfarin, dabigatran etexilate mesylate demonstrated noninferiority for reducing the risk of stroke and systemic embolism, with a dose of 150 mg twice-daily achieving "superiority" over warfarin. In this trial, the incidence of major bleeding was also reduced with dabigatran etexilate mesylate compared to warfarin. In general, evidence suggests that the two agents are comparable in terms of overall bleeding, with more intracranial bleeding being associated with warfarin and more gastrointestinal bleeding being associated with dabigatran etexilate mesylate.[11] Rivaroxaban was compared to warfarin in a large, double-blind trial including over 14,000 patients at risk for stroke. Rivaroxaban demonstrated noninferiority to warfarin in regard to the primary endpoint, a composite of stroke or systemic embolism; however, "superiority" compared to warfarin was not achieved. The incidence of major and clinically relevant nonmajor bleeding between rivaroxaban and warfarin was similar. The rate of intracranial bleeding was significantly lower with rivaroxaban compared to warfarin, but major bleeding from a gastrointestinal site was more common with rivaroxaban.[12]

For the prophylaxis of DVT, rivaroxaban was evaluated in four trials compared to enoxaparin, a low molecular weight heparin agent, for use as thromboprophylaxis in patients undergoing hip and knee replacement surgeries. In all four trials, rivaroxaban significantly reduced the risk of the primary composite endpoint of any DVT, nonfatal PE, or death from any cause compared to enoxaparin. In addition, there were similar rates of major bleeding and hemorrhagic wound complications between rivaroxaban and enoxaparin. The phase III trials evaluated both short (10 to 14 days) and extended (31 to 30 days) thromboprophylaxis with rivaroxaban.[13-16]

As mentioned previously, current standards of care for reducing the risk of stroke in patients with AF include warfarin and aspirin, with warfarin recommended for patients at high risk based on risk factors and past medical history.[8,9,17,18] To date, guidance on the use of dabigatran etexilate mesylate and rivaroxaban is limited. In 2011, the American College of Cardiology Foundation published a focused update on the management of AF with a specific focus on the use of dabigatran etexilate mesylate, which states that the agent is useful as an alternative to warfarin. Rivaroxaban was not approved at this time, and is not addressed in the focused update. Patients who are already receiving warfarin with excellent International Normalized Ratio control may have little to gain by switching to dabigatran etexilate mesylate.[18] Current guidelines from the American College of Chest Physicians (2008) for the prevention of venous thromboembolism also do not address the role of rivaroxaban.[17] The 2010 National Institute for Health and Clinical Excellence and Scottish Intercollegiate Guidelines Network guidelines however both recommend rivaroxaban, along with other traditional antithrombotics, as a potential option for thromboprophylaxis in patients undergoing knee and hip replacement surgeries.[20,21]

References

1. Pradaxa® [package insert]. Ridgefield (CT): Boehringer Ingelheim Pharmaceuticals, Inc.; 2011 Nov.
2. Xarelto® [package insert]. Titusville (NJ): Janssen Pharmaceuticals, Inc.; 2011 Dec.
3. Coumadin® [package insert]. Princeton (NJ): Bristol-Myers Squibb Co.; 2011 Oct.
4. Ansell J, Hirsh J, Hylek E, Jacobson A, Crowther M, Palareti G. Pharmacology and management of the vitamin k antagonists: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines (8th edition). Chest. 2008;133:160S-98S.
5. Drug Facts and Comparisons 4.0 [database on the Internet]. St. Louis: Wolters Kluwer Health, Inc.; 2010 [cited 2012 Jan]. Available from: http://online.factsandcomparisons.com.
6. Micromedex® Healthcare Series [database on the Internet]. Greenwood Village (CO): Thomson Reuters (Healthcare) Inc.; Updated periodically [cited 2012 Jan]. Available from: http://www.thomsonhc.com/.
7. Wann LS, Curtis AB, January CT, Ellenbogen KA, Lowe JE, Estes NAM, et al. 2011 ACCF/AHA/HRS focused updated on the management of patients with atrial fibrillation (updating 2006 guideline): a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol. 2011;57:223-42.
8. Fuster V, Ryden LE, Cannom DS, Crijns HJ, Curtis AB, Ellenbogen KA, et al. American College of Cardiology/American Heart Association/European Society of Cardiology 2006 guidelines for the management of patients with atrial fibrillation-executive summary. Eur Heart J. 2006;27:1979-2030.
9. Singer DE, Albers GW, Dalen JE, Fang MC, Go AS, Halperin JL, et al. Antithrombotic therapy in atrial fibrillation: American College of Chest Physicians Evidence-based Clinical Practice Guidelines (8th edition). Chest. 2008;133:546S-92S.
10. Ma TKW, Yan BP, Lam YY. Dabigatran etexilate vs warfarin as the oral anticoagulant of choice? A review of clinical data. Pharmacol Ther. 2010;129(2):185-94.
11. Connolly SJ, Ezekowitz MD, Yusuf S, Eikelboom J, Oldgren J, Parekh A, et al. Dabigatran vs warfarin in patients with atrial fibrillation. N Engl J Med. 2009;361:1139-51.
12. Patel MR, Mahaffey KW, Garg J, Pan G, Singer DE, Hacke W, et al. Rivaroxaban vs warfarin in nonvalvular atrial fibrillation. N Engl J Med. 2011 Sep 8;365(10):883-91.
13. Eriksson BI, Borris LC, Friedman RJ, Haas S, Huisman M, Kakkar AK, et al. Rivaroxaban vs enoxaparin for thromboprophylaxis after hip arthroplasty. N Engl J Med. 2008 Jun 26;358(26):2765-75.
14. Kakkar AK, Brenner B, Dahl OE, Eriksson BI, Mouret P, Muntz J, et al. Extended duration rivaroxaban vs short-term enoxaparin for the prevention of venous thromboembolism after total hip arthroplasty: a double-blind, randomized controlled trial. Lancet. 2008 Jul 5;372(9632):31-9.
15. Lassen MR, Ageno W, Borris LC, Lieberman JR, Rosencher N, Bandel TJ, et al. Rivaroxaban vs enoxaparin for thromboprophylaxis after total knee arthroplasty. N Engl J Med. 2008 Jun 26;358(26):2776-86.
16. Turpie AG, Lassen MR, Davidson BL, Bauer KA, Gent M, Kwong LM, et al. Rivaroxaban vs enoxaparin for thromboprophylaxis after total knee arthroplasty (RECORD4): a randomized trial. Lancet. 2009 May 16;373(9676):1673-80.
17. Hirsh J, Guyatt C, Albers GW, Harrington R, Schunemann HJ. Executive summary: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines (8th edition). Chest. 2008;133:71S-109S.
18. Wann LS, Curtis AB, Ellenbogen KA, Estes III NA, Ezekowitz MD, Jackman WM, et al. 2011 ACCF/AHA/HRS focused update on the management of patients with atrial fibrillation (update on dabigatran). J Am Coll Cardiol. 2001;57(11):1-8.
19. Kushner FG, Hand M, Smith SC, King III SB, Anderson JL, Antman EM, et al. 2009 Focused update: ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction (updating the 2004 guideline and 2007 focused update) and ACC/AHA/SCAI guidelines on percutaneous coronary intervention (updating the 2005 guideline and 2007 focused update): a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. Circulation. 2009;120:2271-306.
20. National Institute for Health and Clinical Excellence (NICE). Reducing the risk of venous thromboembolism (deep vein thrombosis and pulmonary embolism) in patients admitted to hospital

[guideline on the Internet]. NICE: 2010 [cited 2012 Jan]. Available from: http://guidance.nice.org.uk/CG92.
21. Scottish Intercollegiate Guidelines Network (SIGN). Prevention and management of venous thromboembolism [guideline on the Internet]. SIGN: 2010 [cited 2012 Jan]. Available from: http://www.sign.ac.uk.
22. Antman EM, Anbe DT, Armstrong PW, Bates ER, Green LA, Hand M, et al. ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction-executive summary. J Am Coll Cardiol. 2004;44:671-719.
23. Misselwitz F, Berkowtiz SD, Perzborn E. The discovery and development of rivaroxaban. Ann NY Acad Sci. 2011;1222:64-75.
24. DeLoughery TG. Practical aspects of the oral new anticoagulants. Am J Hematol. 2011;86:586-90.
25. Anderson LV, Vestergaard P, Deichgraeber P, Lindhold JS, Mortenson LS, Frost L. Warfarin for the prevention of systemic embolism in patients with non-valvular atrial fibrillation: a meta-analysis. Heart. 2008 Dec;94(12):1607-13.
26. Saxena R, Koudstaal PJ. Anticoagulants for preventing stroke in patients with nonrheumatic atrial fibrillation and a history of stroke or transient ischemic stroke. Cochrane Database of Systematic Reviews. 2004, Issue 2. Art. No.:CD000185. DOI:10.1002/14651858.CD000185.pub2.
27. Aguilar MI, Hart R. Oral anticoagulants for preventing stroke in patients with non-valvular atrial fibrillation and no previous history of stroke or transient ischemic stroke. Cochrane Database of Systematic Reviews. 2005, Issue 3. Art. No.:CD001927. DOI:10.1002/14651858.CD001927.pub2.
28. Ezekowitz MD, Levine JA. Preventing stroke in patients with atrial fibrillation. JAMA. 1999;281:1830-5.
29. Rothberg MB, Celestin C, Flore LD, Lawler E, Cook JR. Warfarin plus aspirin after myocardial infarction or the acute coronary syndrome: meta-analysis with estimates of risk and benefit. Ann Intern Med. 2005;143:41-250.
30. Hutten BA, Prins MH. Duration of treatment with vitamin K antagonists in symptomatic venous thromboembolism. Cochrane Database of Systematic Reviews. 2006, Issue 1. Art. No.:CD0001367. DOI:10.1002/14651858.CD001367.pub2.
31. van der Heijden JF, Hutten BA, Buller HR, Prins MH. Vitamin K antagonists or low-molecular-weight heparin for the long term management of symptomatic venous thromboembolism. Cochrane Database of Systematic Reviews. 2001, Issue 3. Art. No.:CD002001. DOI:10.1002/14651858.CD002001.
32. Salazar CA, Malaga G, Malasquez G. Direct thrombin inhibitors vs vitamin K antagonists or low molecular weight heparins for prevention of venous thromboembolism following total hip or knee replacement. Cochrane Database of Systematic Reviews. 2010, Issue 4. Art. No.:CD005981. DOI:10.1002/14651858.CD005981.pub2.
33. Brookenthal KR, Freedman KB, Lotke PA, Fitzgerald RH, Lonner JH. A meta-analysis of thromboembolic prophylaxis in total knee arthroplasty. J Arthroplasty. 2001;16(3):293-300.
34. Cundiff DK, Manyemba J, Pezzullo JC. Anticoagulants vs non-steroidal anti-inflammatories or placebo for treatment of venous thromboembolism. Cochrane Database of Systematic Reviews. 2006, Issue 1. Art. No.:CD003746. DOI:10.1002/14651858.CD003746.pub2.
35. Ezekowitz MD, Wallentin L, Connolly SJ, Parekh A, Chernick MR, Pogue J, et al. Dabigatran and warfarin in vitamin K antagonist naïve and experienced cohorts with atrial fibrillation. Circulation. 2010;122:2246-53.
36. Diener HC, Connolly SJ, Ezekowitz MD, Wallentin L, Reilly PA, Yang S, et al. Dabigatran compared to warfarin in patients with atrial fibrillation and previous transient ischemic attack or stroke: a subgroup analysis of the RE-LY trial [abstract]. Lancet Neurol. 2010;12:1157-63.
37. Wallentin L, Yusuf S, Ezekowitz MD, Alings M, Flather M, Franzosi MG, et al. Efficacy and safety of dabigatran compared to warfarin at different levels of international normalized ratio control for stroke prevention in atrial fibrillation: an analysis of the RE-LY trial. Lancet. 2010;376:975-83.
38. Ezekowitz MD, Reilly PA, Nehmiz G, Simmers TA, Nagarakanti R, Parcham-Azad K, et al. Dabigatran with or without concomitant aspirin compared to warfarin alone in patients with nonvalvular atrial fibrillation (PETRO Study). Am J Cardiol. 2007;100:1419-26.
39. Fraker TD Jr, Fihn SD, Gibbons RJ, Abrams J, Chatterjee K, Daley J, et al. 2007 chronic angina focused update of the ACC/AHA 2002 guidelines for the management of chronic stable angina: a

report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines writing group to develop the focused update of the 2002 guidelines for the management of patients with chronic stable angina. Circulation. 2007 Dec 4;116(23):2762-72.
40. Hirsch AT, Haskal ZJ, Hertzer NR, Bakal CW, Creager MA, Halperin JL, et al. ACC/AHA 2005 guidelines for the management of patients with peripheral arterial disease (lower extremity, renal, mesenteric, and abdominal aortic): executive summary: a collaborative report from the American Association for Vascular Surgery/Society for Vascular Surgery, Society for Cardiovascular Angiography and Interventions, Society for Vascular Medicine and Biology, Society of Interventional Radiology, and the ACC/AHA Task Force on Practice Guidelines (writing committee to develop guidelines for the management of patients with peripheral arterial disease). Circulation. 2006;113;1474-547.
41. Jaff MR, McMurtry MS, Archer SL, Cushman M, Goldenberg NA, Goldhaber SZ, et al; on behalf of the American Heart Association Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation, Council on Peripheral Vascular Disease, and Council on Arteriosclerosis, Thrombosis and Vascular Biology. Management of massive and submassive pulmonary embolism, iliofemoral deep vein thrombosis, and chronic thromboembolic pulmonary hypertension: a scientific statement from the American Heart Association. Circulation. 2011 Apr 26;123(16):1788-830.
42. Wright RS, Anderson JL, Adams CD, Bridges CR, Casey DE Jr, Ettinger SM, et al. 2011 ACCF/AHA focused update incorporated into the ACC/AHA 2007 Guidelines for the Management of Patients with Unstable Angina/Non-ST-Elevation Myocardial Infarction: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines developed in collaboration with the American Academy of Family Physicians, Society for Cardiovascular Angiography and Interventions, and the Society of Thoracic Surgeons. J Am Coll Cardiol. 2011 May 10;57(19):e215-367.
43. Hamm CW, Bassand JP, Agewell S, Bax J, Boersma E, Bueno H, et al. ESC guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation: the task force for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation of the European Society of Cardiology. Eur Heart J. 2011 Dec;32(23):2999-3054.
44. National Institute for Health and Clinical Excellence. MI: secondary prevention. Secondary prevention in primary and secondary care for patients following a myocardial infarction. London (UK): National Institute for Health and Clinical Excellence; 2007 May [cited 2012 Jan]. Available from: http://www.nice.org.uk/nicemedia/pdf/CG48NICEGuidance.pdf.
45. Furie KL, Kasner SE, Adams RJ, Albers GW, Bush RL, Fagan SC, et al. Guidelines for the prevention of stroke in patients with stroke or transient ischemic attack: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2011 Jan;42(1):227-76.

- Approval of dabigatran etexilate mesylate for use in atrial fibrillation (AF) was based on the clinical evidence for safety and efficacy derived from the noninferiority, RE-LY trial (N=18,113). After a median follow-up duration of two years, dabigatran etexilate mesylate 110 mg twice-daily was associated with similar rates of stroke and systemic embolism compared to warfarin (*P*=0.34), while dabigatran 150 mg twice-daily was associated with a significantly lower rate (*P*<0.001). Rates of major bleeding were similar between warfarin and dabigatran etexilate mesylate 150 mg twice-daily (*P*=0.31), but significantly less with dabigatran etexilate mesylate 110 mg twice-daily (*P*=0.003).[16]
    - For the secondary endpoints evaluated, no differences were observed between the two treatments with regard to death from any cause and pulmonary embolism (PE); however, the rate of myocardial infarction was significantly higher (*P*=0.048 with dabigatran etexilate mesylate 150 mg vs warfarin) and the rate of hospitalization significantly lower (*P*=0.003 with dabigatran etexilate mesylate 110 mg vs warfarin) with dabigatran etexilate mesylate.
- Approval of rivaroxaban for use in AF was based on the clinical evidence for safety and efficacy derived from the noninferiority, ROCKET-AF trial (N=14,264). Results demonstrated that rivaroxaban (15 or 20 mg/day) is noninferior to warfarin for the prevention of stroke or systemic embolism (*P*<0.001 for noninferiority), with no increased risk of major bleeding (*P*=0.44). Within ROCKET-AF, intracranial and fatal bleeding were significantly less frequent with rivaroxaban (*P*=0.02).[17]
- Approval of rivaroxaban for prophylaxis of deep vein thrombosis (DVT) was based on the clinical evidence for safety and efficacy derived from the global program of clinical trials known collectively as RECORD (1 [N=4,541], 2 [N=2,509], 3 [2,531], and 4 [N=3,148]). All four trials compared rivaroxaban to enoxaparin for thromboprophylaxis in patients undergoing total elective hip and knee replacement surgeries.[18-21]
    - In all four trials, rivaroxaban significantly reduced the risk of the primary composite endpoint of any DVT, nonfatal PE, or death from any cause compared to enoxaparin, with no increased risk of major bleeding, any bleeding, and hemorrhagic wound complications.

Key Points within the Medication Class

- According to Current Clinical Guidelines:
    - Current guidelines support the use of the oral anticoagulants for Food and Drug Administration-approved indications; however, due to the relatively recent approval of dabigatran etexilate mesylate and rivaroxaban there is little guidance as to role of these agents in therapy.
    - Atrial fibrillation:[22-26]
        - Standard anticoagulation therapy consists of vitamin K antagonists, such as warfarin, and aspirin. Use of either agent is dependent on patient specific risk factors and past medical history.
        - The 2011 American College of Cardiology Foundation focused update states that dabigatran etexilate mesylate is useful as an alternative to warfarin, and patients already receiving warfarin with excellent International Normalized Ratio control may have little to gain by switching to dabigatran etexilate mesylate.[26]
    - Thromboprophylaxis:[22,27,28]
        - The 2008 American College of Chest Physicians guideline recommends the routine use of a low molecular weight heparin agent, fondaparinux, or a vitamin K antagonist for the prevention of venous thromboembolism in patients undergoing an orthopedic surgery.[22]
        - The more recent 2010 National Institute for Health and Clinical Excellence and Scottish Intercollegiate Guidelines Network guidelines recommend rivaroxaban, along with traditional antithrombotics, for thromboprophylaxis in these surgeries.[27,28]
    - Secondary prevention in post-myocardial infarction:[22,29-33]
        - Warfarin is recommended in post-myocardial infarction patients who have an indication for anticoagulation; however, the evidence surrounding its use in these patients is still evolving.
- Other Key Facts:
    - Rivaroxaban for use in atrial fibrillation:[3,17]

- The approved package labeling for rivaroxaban acknowledges the low percentage of "time in International Normalized Ratio range" for patients randomized to warfarin within the ROCKET-AF trial as compared to other clinical trials, and states that it is unknown how rivaroxaban compares when patients are well controlled on warfarin.
- Within the ROCKET-AF trial, an increased incidence of adverse clinical events were noted when patients were transitioned off of rivaroxaban to warfarin or to another vitamin K antagonist.

o Warfarin is available generically.

References

1. Pradaxa® [package insert]. Ridgefield (CT): Boehringer Ingelheim Pharmaceuticals, Inc.; 2011 Nov.
2. Xarelto® [package insert]. Titusville (NJ): Janssen Pharmaceuticals, Inc.; 2011 Dec.
3. Coumadin® [package insert]. Princeton (NJ): Bristol-Myers Squibb Co.; 2011 Oct.
4. Ansell J, Hirsh J, Hylek E, Jacobson A, Crowther M, Palareti G. Pharmacology and management of the vitamin k antagonists: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines (8th edition). Chest. 2008;133:160S-98S.
5. Ma TKW, Yan BP, Lam YY. Dabigatran etexilate vs warfarin as the oral anticoagulant of choice? A review of clinical data. Pharmacol Ther. 2010;129(2):185-94.
6. Anderson LV, Vestergaard P, Deichgraeber P, Lindhold JS, Mortenson LS, Frost L. Warfarin for the prevention of systemic embolism in patients with non-valvular atrial fibrillation: a meta-analysis. Heart. 2008 Dec;94(12):1607-13.
7. Saxena R, Koudstaal PJ. Anticoagulants for preventing stroke in patients with nonrheumatic atrial fibrillation and a history of stroke or transient ischemic stroke. Cochrane Database of Systematic Reviews. 2004, Issue 2. Art. No.:CD000185. DOI:10.1002/14651858.CD000185.pub2.
8. Aguilar MI, Hart R. Oral anticoagulants for preventing stroke in patients with non-valvular atrial fibrillation and no previous history of stroke or transient ischemic stroke. Cochrane Database of Systematic Reviews. 2005, Issue 3. Art. No.:CD001927. DOI:10.1002/14651858.CD001927.pub2.
9. Ezekowitz MD, Levine JA. Preventing stroke in patients with atrial fibrillation. JAMA. 1999;281:1830-5.
10. Rothberg MB, Celestin C, Flore LD, Lawler E, Cook JR. Warfarin plus aspirin after myocardial infarction or the acute coronary syndrome: meta-analysis with estimates of risk and benefit. Ann Intern Med. 2005;143:41-250.
11. Hutten BA, Prins MH. Duration of treatment with vitamin K antagonists in symptomatic venous thromboembolism. Cochrane Database of Systematic Reviews. 2006, Issue 1. Art. No.:CD0001367. DOI:10.1002/14651858.CD001367.pub2.
12. van der Heijden JF, Hutten BA, Buller HR, Prins MH. Vitamin K antagonists or low-molecular-weight heparin for the long term management of symptomatic venous thromboembolism. Cochrane Database of Systematic Reviews. 2001, Issue 3. Art. No.:CD002001. DOI:10.1002/14651858.CD002001.
13. Salazar CA, Malaga G, Malasquez G. Direct thrombin inhibitors vs vitamin K antagonists or low molecular weight heparins for prevention of venous thromboembolism following total hip or knee replacement. Cochrane Database of Systematic Reviews. 2010, Issue 4. Art. No.:CD005981. DOI:10.1002/14651858.CD005981.pub2.
14. Brookenthal KR, Freedman KB, Lotke PA, Fitzgerald RH, Lonner JH. A meta-analysis of thromboembolic prophylaxis in total knee arthroplasty. J Arthroplasty. 2001;16(3):293-300.
15. Cundiff DK, Manyemba J, Pezzullo JC. Anticoagulants vs non-steroidal anti-inflammatories or placebo for treatment of venous thromboembolism. Cochrane Database of Systematic Reviews. 2006, Issue 1. Art. No.:CD003746. DOI:10.1002/14651858.CD003746.pub2.
16. Connolly SJ, Ezekowitz MD, Yusuf S, Eikelboom J, Oldgren J, Parekh A, et al. Dabigatran vs warfarin in patients with atrial fibrillation. N Engl J Med. 2009;361:1139-51.
17. Patel MR, Mahaffey KW, Garg J, Pan G, Singer DE, Hacke W, et al. Rivaroxaban vs warfarin in nonvalvular atrial fibrillation. N Engl J Med. 2011 Sep 8;365(10):883-91.
18. Eriksson BI, Borris LC, Friedman RJ, Haas S, Huisman M, Kakkar AK, et al. Rivaroxaban vs enoxaparin for thromboprophylaxis after hip arthroplasty. N Engl J Med. 2008 Jun 26;358(26):2765-75.
19. Kakkar AK, Brenner B, Dahl OE, Eriksson BI, Mouret P, Muntz J, et al. Extended duration rivaroxaban vs short-term enoxaparin for the prevention of venous thromboembolism after total hip arthroplasty: a double-blind, randomized controlled trial. Lancet. 2008 Jul 5;372(9632):31-9.
20. Lassen MR, Ageno W, Borris LC, Lieberman JR, Rosencher N, Bandel TJ, et al. Rivaroxaban vs enoxaparin for thromboprophylaxis after total knee arthroplasty. N Engl J Med. 2008 Jun 26;358(26):2776-86.
21. Turpie AG, Lassen MR, Davidson BL, Bauer KA, Gent M, Kwong LM, et al. Rivaroxaban vs enoxaparin for thromboprophylaxis after total knee arthroplasty (RECORD4): a randomized trial. Lancet. 2009 May 16;373(9676):1673-80.
22. Hirsh J, Guyatt C, Albers GW, Harrington R, Schunemann HJ. Executive summary: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines (8th edition). Chest. 2008;133:71S-109S.
23. Wann LS, Curtis AB, January CT, Ellenbogen KA, Lowe JE, Estes NAM, et al. 2011 ACCF/AHA/HRS focused updated on the management of patients with atrial fibrillation (updating 2006 guideline): a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol. 2011;57:223-42.
24. Fuster V, Ryden LE, Cannom DS, Crijns HJ, Curtis AB, Ellenbogen KA, et al. American College of Cardiology/American Heart Association/European Society of Cardiology 2006 guidelines for the management of patients with atrial fibrillation-executive summary. Eur Heart J. 2006;27:1979-2030.
25. Singer DE, Albers GW, Dalen JE, Fang MC, Go AS, Halperin JL, et al. Antithrombotic therapy in atrial fibrillation: American College of Chest Physicians Evidence-based Clinical Practice Guidelines (8th edition). Chest. 2008;133:546S-92S.

26. Wann LS, Curtis AB, Ellenbogen KA, Estes III NA, Ezekowitz MD, Jackman WM, et al. 2011 ACCF/AHA/HRS focused update on the management of patients with atrial fibrillation (update on dabigatran). J Am Coll Cardiol. 2001;57(11):1-8.
27. National Institute for Health and Clinical Excellence (NICE). Reducing the risk of venous thromboembolism (deep vein thrombosis and pulmonary embolism) in patients admitted to hospital [guideline on the Internet]. NICE: 2010 [cited 2012 Jan]. Available from: http://guidance.nice.org.uk/CG92.
28. Scottish Intercollegiate Guidelines Network (SIGN). Prevention and management of venous thromboembolism [guideline on the Internet]. SIGN: 2010 [cited 2012 Jan]. Available from: http://www.sign.ac.uk.
29. Kushner FG, Hand M, Smith SC, King III SB, Anderson JL, Antman EM, et al. 2009 Focused update: ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction (updating the 2004 guideline and 2007 focused update) and ACC/AHA/SCAI guidelines on percutaneous coronary intervention (updating the 2005 guideline and 2007 focused update): a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. Circulation. 2009;120:2271-306.
30. Antman EM, Anbe DT, Armstrong PW, Bates ER, Green LA, Hand M, et al. ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction-executive summary. J Am Coll Cardiol. 2004;44:671-719.
31. Wright RS, Anderson JL, Adams CD, Bridges CR, Casey DE Jr, Ettinger SM, et al. 2011 ACCF/AHA focused update incorporated into the ACC/AHA 2007 Guidelines for the Management of Patients with Unstable Angina/Non-ST-Elevation Myocardial Infarction: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines developed in collaboration with the American Academy of Family Physicians, Society for Cardiovascular Angiography and Interventions, and the Society of Thoracic Surgeons. J Am Coll Cardiol. 2011 May 10;57(19):e215-367.
32. Hamm CW, Bassand JP, Agewell S, Bax J, Boersma E, Bueno H, et al. ESC guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation: the task force for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation of the European Society of Cardiology. Eur Heart J. 2011 Dec;32(23):2999-3054.
33. National Institute for Health and Clinical Excellence. MI: secondary prevention. Secondary prevention in primary and secondary care for patients following a myocardial infarction. London (UK): National Institute for Health and Clinical Excellence; 2007 May [cited 2012 Jan]. Available from: http://www.nice.org.uk/nicemedia/pdf/CG48NICEGuidance.pdf.