Prevention of Postoperative Venous Thromboembolism: An Update

G. Patrick Clagett, MD, Dallas, Texas

BACKGROUND: Perioperative venous thromboembolism remains a major health problem. Each year, approximately 260,000 cases are diagnosed clinically, and the incidence of asymptomatic and undiagnosed cases is far greater. Despite the availability of effective strategies to prevent venous thromboembolism, prophylaxis is underutilized. According to recent epidemiologic surveys, approximately two thirds of hospitalized patients with clinical risk factors for venous thromboembolism do not receive adequate prophylaxis.

METHODS: A comprehensive review of the English language literature was carried out to define effective antithrombotic regimens to prevent venous thromboembolism in discrete surgical patient populations. Reliable data are available for every group with the exception of patients with multiple trauma and spinal cord injury.

CONCLUSIONS: A wide variety of effective prophylactic methods are available to prevent venous thromboembolism. Individual patients can be assigned a level of risk based on clinical risk factors. The choice of prophylactic method is based on the level of risk, potential for complications, and costs. With the wide availability of proven methods, no patient at risk for venous thromboembolism should be left unprotected.

It has been estimated that venous thromboembolism causes over 100,000 deaths each year in the United States and is a contributing factor in another 100,000. Although approximately 50% of these patients have terminal illnesses that are complicated by pulmonary embolism, many have treatable conditions and would have extended longevity were it not for their embolisms. These estimates are from relatively old, crude data. However, they have been substantiated in a contemporary study conducted in 16 short-stay community hospitals in central Massachusetts, where the annual incidence of verified pulmonary embolism was 23 per 100,000 residents with an in-hospital case fatality rate of 12%.

Extrapolation of these data to the U.S. population suggests that approximately 260,000 cases of clinically diagnosed venous thromboembolism occur each year in patients hospitalized in acute care hospitals in this country.

However, because pulmonary embolism is underdiagnosed, this represents the tip of the iceberg. Fatal and nonfatal pulmonary emboli are most often clinically silent, with the disease being unsuspected before death in 70% to 80% of patients in whom the diagnosis is made at autopsy. Because of the low rate of autopsy in the United States and the failure of the Massachusetts study to include nonacute care facilities such as nursing homes and rehabilitation hospitals, where the incidence of pulmonary embolism is probably even higher, the real incidence of venous thromboembolism is far greater. These concerns are justified based on data from population studies in countries where the rate of autopsy is much higher and the recorded incidence of fatal pulmonary embolism is correspondingly greater.

THE PROS AND CONS OF PROPHYLAXIS

A fundamental reason for prophylaxis of venous thromboembolism is the clinically silent nature of the disease. Deep venous thrombosis and pulmonary embolism show few specific symptoms, and the clinical diagnosis based on history and physical examination alone is insensitive and woefully unreliable. In addition, waiting until venous thromboembolism becomes clinically evident before treating the condition exposes susceptible patients to unacceptable risks. The first sign of the disease may be fatal pulmonary embolism. Although anticoagulation is highly effective therapy, the majority of patients who die from pulmonary embolism do so within 1/2 hour of the onset of symptoms, too soon for anticoagulant therapy to be effective. Unrecognized and untreated deep venous thrombosis may also lead to long-term sequelae such as chronic venous insufficiency and the postphlebitic syndrome, and it predisposes some patients to recurrent venous thromboembolism.

In addition to saving lives and reducing morbidity, health care costs are reduced by broad application of preventive measures. All cost-effectiveness studies have documented that it is far less expensive to employ routine prophylaxis than to pay for treatment of clinically recognized venous thromboembolism. A recent study that examined the prevalence of risk factors for venous thromboembolism in hospitalized patients in the United States addressed the costs of prophylaxis to the patients at risk. The authors estimated that for the 1.2 million patients over the age of 40 years undergoing major surgery each year, the total cost of prophylaxis, estimated to be $50 to $100 per patient, would be $59 million to $118 million. If effective prophylaxis would prevent 158,000 episodes of deep venous thrombosis and 6,000 deaths from pulmonary embolism. The cost savings would be $119 million to $301 million. In addition, the authors estimated that there were 6 million patients hospitalized annually for medical and other surgical conditions who were also at high risk for venous thromboembolism.

From the Division of Vascular Surgery, University of Texas Southwestern Medical Center, Dallas, Texas.
Requests for reprints should be addressed to G. Patrick Clagett, MD, Section of Vascular Surgery, University of Texas Southwestern Medical Center, 5323 Harry Hines Boulevard, Dallas, Texas 75235-9031.

thromboembolism. The general application of prophylaxis to all such patients might prevent 700,000 episodes of deep venous thrombosis and 25,000 to 33,000 deaths from pulmonary embolism each year. This would represent a savings of $330 million to $660 million.

An alternative to prophylaxis would be to use serial surveillance tests, such as duplex ultrasonography, in high-risk patients. Although attractive, this approach is expensive, time consuming, and cumbersome. It can, therefore, only be applied to limited numbers of patients at risk. Also, these methods detect deep venous thrombosis with less sensitivity in asymptomatic patients who may have partially occlusive or distal thrombi than in symptomatic patients. Most experts believe that wide application of effective methods of prevention is safer and more cost effective than selective, intensive surveillance.

Despite overwhelming evidence of the efficacy of a wide variety of prophylactic agents, surveys conducted in the United States, England, and Sweden document wide practice variations among physicians. Approximately one half of surgeons in these countries use prophylaxis in less than one fifth of their patients. A recent study of over 2,000 patients with multiple risk factors hospitalized at 16 acute care hospitals showed that only approximately one third received prophylaxis. Use of prophylaxis was higher in teaching than nonteaching hospitals, and patients undergoing vascular, abdominal, and orthopedic operations were the most likely to receive prophylaxis. Risk factors for venous thromboembolism were highly prevalent in this population of hospitalized patients. Seventy-eight percent had 1 or more risk factors, 48% had 2 or more, and 19% had 3 or more. The authors concluded that despite widespread recognition of the problem and the effectiveness of multiple prophylactic strategies, prophylaxis is currently underutilized.

Why don't more physicians use routine prophylaxis? Many feel that the overall incidence of venous thromboembolism among hospitalized and postoperative patients has decreased over the past decades to the point where the incidence is too low to consider prophylaxis. In other words, they believe perioperative venous thromboembolism is no longer a significant problem. These individuals will frequently cite informal, retrospective surveys of their own clinical services and the rare occurrence of fatal pulmonary embolism diagnosed by autopsy at their hospital to bolster this argument. The incidence of venous thromboembolism has, in fact, declined in recent years, and this most likely reflects the success of prophylactic strategies. Even so, the incidence remains too high for a condition that is preventable, and current estimates of the incidence of fatal pulmonary embolism based on hospital discharge data suggest the need for even wider application of prophylaxis. Furthermore, the difficulty of establishing the antemortem diagnosis of pulmonary embolism has been alluded to as well as the low rate of autopsy in the United States, especially in elderly patients with chronic conditions. Data from countries where autopsy is mandated indicate that pulmonary embolism remains a significant problem. In addition, contemporary data from the central Massachusetts study show that even clinically recognized pulmonary embolism is surprisingly common.

Another reason physicians omit prophylaxis, especially in surgical patients, is concern about bleeding complications. Countering this worry are abundant data from meta-analyses and placebo-controlled, double-blind randomized trials that demonstrate no significant increase in major bleeding with the use of low-dose heparin and low-molecular-weight heparin. The incidence of wound hematomas is increased with these agents and this can result in wound infection, dehiscence, and infection of a prosthetic device placed at the time of operation. The magnitude and importance of this problem have, unfortunately, been unappreciated or ignored by many advocates of prophylaxis who are not surgeons. However, alternative, mechanical methods of effective prophylaxis that carry no bleeding risk are available for such patients. Heparin-induced thrombocytopenia has also been raised as a concern with widespread use of low-dose heparin and other heparin compounds. Critical review of this problem, though, suggests that the incidence with this route of heparin administration is vanishingly rare. In addition, the costs of prophylaxis have also been used as an argument against its wider use. However, as pointed out above, every study addressing this issue has concluded that routine prophylaxis is highly cost effective.

The least frequently expressed reason for not using prophylaxis has to do with subjective perceptions of the magnitude of the problem and the effects of prophylaxis in individual practices. Because venous thromboembolism is most often clinically silent, the occurrence of diagnosed venous thromboembolism among an individual physician's patients is perceived to be rare. For example, ex-

<table>
<thead>
<tr>
<th>Table I: Classification of Level of Risk</th>
<th>Low Risk (^a)</th>
<th>Moderate Risk (^b)</th>
<th>High Risk (^c)</th>
<th>Very High Risk (^d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calf vein thrombosis (%)</td>
<td>2</td>
<td>10-20</td>
<td>20-40</td>
<td>40-80</td>
</tr>
<tr>
<td>Proximal vein thrombosis (%)</td>
<td>0.4</td>
<td>2-4</td>
<td>4-8</td>
<td>10-20</td>
</tr>
<tr>
<td>Clinical pulmonary embolism (%)</td>
<td>0.2</td>
<td>1-2</td>
<td>4-10</td>
<td>4-10</td>
</tr>
<tr>
<td>Fatal pulmonary embolism (%)</td>
<td>0.002</td>
<td>0.1-0.4</td>
<td>0.4-1.0</td>
<td>1-5</td>
</tr>
</tbody>
</table>

\(^a\)Low risk is defined as uncomplicated surgery in patients under age 40 who have no other clinical risk factors.

\(^b\)Moderate risk is defined as major surgery in patients over age 40 who have no other clinical risk factors.

\(^c\)High risk is defined as major surgery in patients over age 40 who have additional risk factors or myocardial infarction.

\(^d\)Very high risk is defined as major surgery in patients over age 40 plus previous venous thromboembolism, malignant disease, orthopedic surgery, hip fracture, stroke, or spinal cord injury.
The extrapolation of data from meta-analyses suggests that fatal pulmonary embolism occurs in 0.5% to 0.8% of patients over the age of 40 years who undergo abdominal surgery without prophylaxis, and in many of these, the diagnosis would not be known. Similarly, proximal or above-knee venous thrombosis is present in 6% to 7% of general surgical patients, and at least 50% of these thromboses would be clinically silent and not detected. Therefore, an average busy general surgeon whose practice consists of a high volume of major abdominal surgery would not perceive venous thromboembolism to be a major problem. More importantly, this physician would have little appreciation of the effectiveness of, say, low-dose heparin in lowering the incidence of fatal pulmonary embolism in his/her individual practice. The reduction would be on the order of from 0.7% to 0.2%, based on extrapolation of data from meta-analyses dealing with large numbers of patients. Physicians may underestimate the efficacy of prophylaxis not only because many of the prevented cases would have been discovered, but also because cases where patients develop venous thromboembolism despite prophylaxis are clinically overt and readily apparent. In addition, bleeding complications are highly visible, vexing, and are frequently blamed on prophylaxis.

**CLINICAL RISK FACTORS**

Application of effective prophylaxis depends upon knowledge of specific risk factors in individual patients. Clinical risk factors include age >40 years (and more strongly, age >70 years); prolonged immobility or paralysis; prior venous thromboembolism; cancer; major surgery (particularly operations involving the abdomen, pelvis, and lower extremities); obesity; varicose veins; congestive heart failure; myocardial infarction; stroke; extensive lower extremity soft-tissue trauma; high-dose estrogen use; and fractures of the pelvis, hip, or leg. In addition, congenital and acquired aberrations in hemostatic mechanisms (hypercoagulable states) that ordinarily predispose to venous thromboembolism assume even greater risk when afflicted patients are hospitalized and undergo surgical procedures. Hemostatic abnormalities include antithrombin III deficiency, protein C deficiency, acquired or congenital resistance to activated protein C, protein S deficiency, dysfibrinogenemia, disorders of plasminogen and plasminogen activation, antiphospholipid antibodies and lupus anticoagulant, heparin-induced thrombocytopenia, myeloproliferative disorders such as polycythemia vera, and hyperviscosity syndromes.

In the common situation where a patient has more than one risk factor, the risks are cumulative. For example, elderly patients with hip fractures undergoing major orthopedic surgery who remain immobile in bed postoperatively are among the most vulnerable to fatal pulmonary embolism. Successful application of prophylaxis also depends upon awareness of the risk of venous thromboembolism in general patient categories and clinical settings where the risk has been defined by epidemiologic studies. For example, the overall incidence of venous thromboembolism is higher on orthopedic services and in intensive care units than on general medical services. The levels of risk of thromboembolic events based on clinical risk factors and epidemiologic data are shown in Table 1.

**METHODS AND RESULTS OF PROPHYLAXIS**

Just as levels of risk vary in individual patients, so too do the efficacies of prophylactic strategies. A successful approach in one type of patient may be relatively ineffective in another. For example, low-dose heparin is very effective in moderate-risk general surgery patients, but is a

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**TABLE II**

<table>
<thead>
<tr>
<th>Antithrombotic Regimens to Prevent Venous Thromboembolism</th>
<th>Description</th>
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<tbody>
<tr>
<td>Low-dose heparin</td>
<td>5,000 U heparin given subcutaneously every 8–12 hours, starting 1–2 hours before surgery</td>
</tr>
<tr>
<td>Adjusted-dose subcutaneous heparin</td>
<td>3,500 U heparin given subcutaneously every 8 hours with postoperative dose adjustment by ± 500 U to maintain APTT at high-normal values</td>
</tr>
<tr>
<td>Heparin/DHE (dihydergotamine)</td>
<td>2,500–5,000 U heparin + 0.5 mg DHE given subcutaneously every 12 hours</td>
</tr>
<tr>
<td>Low-molecular-weight heparin and heparinoids</td>
<td>Various doses, depending on preparation, given subcutaneously once or twice daily</td>
</tr>
<tr>
<td>Moderate-dose perioperative warfarin</td>
<td>Start moderate daily dose (5 mg) the day of or the day after surgery; adjust dose for prothrombin time ratio 1.3–1.5 (INR 2:3) by day 5</td>
</tr>
<tr>
<td>Pre- and postoperative two-step warfarin</td>
<td>Start 1–2.5 mg/d 5–14 days before surgery aiming for 2–3 second increase in prothrombin time during surgery; give 2.5–5 mg/d aiming for prothrombin time ratio of 1.3–1.5 (INR 2:3) in the postoperative period</td>
</tr>
<tr>
<td>Minidose warfarin</td>
<td>Start 1 mg/d 10–14 days before surgery, aiming for INR = 1.5 after surgery</td>
</tr>
<tr>
<td>Dextran 40/70</td>
<td>500–1,000 mL dextran 40 or 70 during surgery, then 500 mL daily for 3 days, then every other day</td>
</tr>
<tr>
<td>Aspirin</td>
<td>325–3,600 mg/d</td>
</tr>
<tr>
<td>Intermittent pneumatic compression/elastic stocking</td>
<td>Start immediately before surgery and continue until fully ambulatory</td>
</tr>
</tbody>
</table>

APTT = activated partial thromboplastin time; INR = International Normalized Ratio.
<table>
<thead>
<tr>
<th>Patient Category</th>
<th>No Prophylaxis</th>
<th>Low-Dose Heparin</th>
<th>Low-Dose Dihydroergotamine</th>
<th>Subcutaneous Heparin</th>
<th>Warfarin</th>
<th>Dextran</th>
<th>Aparin</th>
<th>Elastic Compression</th>
<th>Intermittent Pneumatic Compression</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Surgery</td>
<td>25</td>
<td>68</td>
<td>86</td>
<td>1</td>
<td>59</td>
<td>38</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elective Hip</td>
<td>46-55</td>
<td>32</td>
<td>68</td>
<td>43</td>
<td>77</td>
<td>63</td>
<td>41</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Replacement</td>
<td>43</td>
<td>38-49</td>
<td>9</td>
<td>24</td>
<td>2</td>
<td>7</td>
<td>43</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Hip fracture</td>
<td>24</td>
<td>20-28</td>
<td>75</td>
<td>38</td>
<td>2</td>
<td>2</td>
<td>43</td>
<td>32</td>
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</tr>
</tbody>
</table>

Total effects of prophylaxis. The percentages of pooled analysis of English language reports through 1992. The venous thrombosis (VT) diagnosis was based on the following criteria: major lower extremity swelling, pain, and/or D-dimer assay, and/or venography, and/or multiple events. Probabilistic prevention of deep vein thrombosis is necessary for postoperative patients, including those patients undergoing major abdominal surgery, gynecological, gynecological, and urological procedures. The data on the incidence of at least 50% is due to the insufficient number of patients. These percentages do not include patients with multiple events. The incidence of at least 50% is due to the insufficient number of patients. The data on the incidence of at least 50% is due to the insufficient number of patients. The data on the incidence of at least 50% is due to the insufficient number of patients. The data on the incidence of at least 50% is due to the insufficient number of patients. The data on the incidence of at least 50% is due to the insufficient number of patients.
poor choice in high-risk orthopedic patients. In addition to relative effectiveness, the risk of bleeding and expense vary with different agents. An underlying philosophy of broad application of prophylaxis is that many patients will be treated in order to prevent venous thromboembolism in a few. Therefore, costly strategies with significant bleeding potential should be reserved for patients at highest risk. For example, moderate intensity warfarin (International Normalized Ratio, INR = 2 to 3) is an excellent choice in high-risk orthopedic patients, but would be inappropriate in moderate-risk general surgery patients. Prophylactic regimens proven to be effective are outlined in Table II.

The results of prophylactic strategies in various patient groups are shown in Table III. Effectiveness is defined by the relative risk reduction of deep venous thrombosis, the precursor to pulmonary embolism. These data were derived from pooled analyses of the results of randomized trials published in English. The following recommendations in various patient categories were made by a consensus group that critically reviewed these data, applied formal statistical rules of evidence to judge efficacy, extrapolated results from studies in similar patient groups when data were insufficient, and tempered their recommendations with practical concerns of cost, patient acceptance, and physician and nursing compliance.

**GENERAL SURGERY**

The overall incidence of thromboembolic end points in general surgical patients was calculated by pooling data from control patients in published English language trials of prophylactic methods. In most trials, the bulk of these patients had elective gastrointestinal surgery. However, some of the patient populations were more heterogeneous and included individuals undergoing gynecologic, thoracic, urologic, and vascular operations. The overall incidence of deep venous thrombosis as assessed by the labeled fibrinogen uptake test was 25% in control subjects. In trials in which the fibrinogen uptake test was confirmed by phlebography, the incidence was 19%. Most of this represents calf or leg vein thrombosis of little clinical significance. The presence of more serious proximal or above-knee deep venous thrombosis was 6% to 7% in patients not treated with prophylaxis. The overall incidence of clinically recognized pulmonary embolism (fatal and nonfatal) was 1.6% and the incidence of fatal pulmonary embolism, 0.8%. In low-risk general surgery patients who are undergoing minor operations, are less than 40 years of age, and have no clinical risk factors, no specific prophylaxis other than early ambulation is warranted. Elastic stockings, low-dose heparin (given every 12 hours), or intermittent pneumatic compression would be appropriate for moderate-risk general surgery patients who are over 40 years of age and are undergoing major operations, but who have no additional clinical risk factors for venous thromboembolism.

Low-dose heparin (given every 8 hours) or low-molecular-weight heparin should be used in higher-risk general surgery patients who are over the age of 40 years, undergoing major operations, and have additional risk factors. In very high-risk general surgery patients with multiple risk factors, pharmacologic methods (low-dose heparin, low-molecular-weight heparin, or dextran) may be combined with intermittent pneumatic compression. In selected, very-high-risk general surgery patients, perioperative low-to-moderate intensity warfarin may be an appropriate choice.

Low-molecular-weight heparin appears to be only slightly better than low-dose unfractionated heparin in preventing venous thromboembolism (Table III) and may be associated with slightly fewer bleeding complications. It is also more convenient and can be administered in a single-daily-dosage regimen. However, both strategies are highly successful in high-risk patients, and the marginal advantages of low-molecular-weight heparin may be offset by its higher expense. At present prices, low-molecular-weight heparin costs about tenfold more per dose than low-dose heparin. Low-dose heparin combined with dihydroergotamine is also effective, but has been withdrawn from the market in the United States. Higher-risk general surgery patients who are prone to wound complications such as hematomas and infection, dextran or intermittent pneumatic compression would be good alternative choices for prophylaxis. These agents have been proven effective in multiple trials and carry less bleeding risk. Recent data indicate that low-molecular-weight heparin also causes fewer wound hematomas than does low-dose unfractionated heparin.

Aspirin has generally been found to be ineffective in preventing venous thromboembolism in general surgery patients and has not been recommended as an appropriate strategy. This view has been challenged by a recently published meta-analysis of the Antithrombotic Trialists’ Collaboration that concluded that perioperative aspirin treatment reduced the incidence of deep venous thrombosis in general surgery patients by 37% and pulmonary embolism by 71% in comparison to untreated controls. These reductions were highly significant and similar effects were reported in patients undergoing orthopedic and other operations. Because of its low expense, ease of administration, and lack of side effects, aspirin would appear to be an ideal antithrombotic agent to prevent venous thromboembolism. However, a closer scrutiny of the Antithrombotic Trialists’ Collaboration group’s methodology leads to questions about the benefit of aspirin. They analyzed collectively more than 30 aspirin trials of variable scientific quality. Such an inclusive approach may allow subtle biases present in some trials to be magnified when subjected to meta-analysis.

Another recent meta-analysis that included only scientifically credible trials concluded against the efficacy of aspirin. In this analysis, trial eligibility criteria included proper randomization of patients to aspirin or control groups, appropriate diagnostic tests (fibrinogen uptake test confirmed by venography, or venography in all patients), and interpretation of tests without knowledge of treatment. Only six trials in general surgery patients fulfilled these criteria, and aspirin-treated patients and controls had similar incidences of deep venous thrombosis. The authors concluded that aspirin is of no benefit in preventing venous thromboembolism in general surgery patients. In orthopedic patients there was a modest but significant benefit, but much less than other forms of prophylaxis.
ORTHOPEDIC SURGERY

Orthopedic operations and orthopedic trauma are high-risk events in which the most frequent cause of death is often pulmonary embolism. In patients not receiving prophylaxis, deep venous thrombosis complicates the postoperative course after total hip replacement in approximately 50% of patients. \(^{29,42,43}\) Fatal pulmonary embolism occurs in up to 6% of patients who are not treated with prophylaxis. \(^{44}\) The mortality of hip fractures without prophylaxis is over 3% and may be as high as 12%, with pulmonary embolism being the most common cause of death. \(^{44}\) After knee replacement surgery, the incidence of deep venous thrombosis is over 50% and may reach 80%. \(^{45-47}\)

In patients undergoing total hip replacement, warfarin and low-molecular-weight heparin are the most effective antithrombotic agents (Table III). The results from a recent, large randomized trial indicated that the small reduction in the incidence of venous thromboembolism with low-molecular-weight heparin, as compared with warfarin, was offset by an increase in bleeding complications. \(^{48}\) Nevertheless, low-molecular-weight heparin was at least as effective as warfarin and is much simpler to administer. Although other methods such as low-dose heparin, dextran, aspirin, intermittent pneumatic compression, and elastic stockings reduce the overall incidence of venous thromboembolism, they are less effective and should not be used routinely. Subcutaneous heparin given in adjusted doses to maintain the activated partial thromboplastin time in the upper normal range has also been found to be highly effective. \(^{49,50}\) However, this method of administration is cumbersome, requires close monitoring, and is not commonly used.

Warfarin and low-molecular-weight heparin are the most effective prophylactic agents in patients with hip fractures. Dextran, low-dose heparin, and aspirin are less effective and are not recommended for routine use (Table III). Placement of a prophylactic inferior vena cava filter may be considered in selected high-risk orthopedic-trauma patients in whom other forms of prophylaxis would be contraindicated or ineffective. \(^{51,52}\)

NEUROSURGERY/ACUTE SPINAL CORD INJURY/MULTIPLE TRAUMA

Patients undergoing elective intracranial neurosurgery are at high risk for venous thromboembolism because they frequently have paralysis, prolonged postoperative immobility, and often have lengthy operations with the lower extremities in a dependent position. In control patients not treated with prophylaxis, the average incidence of deep venous thrombosis is approximately 24% (Table III). Physical methods of prophylaxis in neurosurgical patients have been preferred to anticoagulant therapy because of concern about intracranial bleeding. Intermittent pneumatic compression with or without elastic stockings is the prophylactic method of choice in these patients.

Although the high incidence of deep venous thrombosis in patients with hip and lower-extremity fractures is well established, the incidence following other types of trauma is less well known. The literature is difficult to interpret because trauma patients are heterogeneous with a variety of injuries, and studies reporting a high incidence of deep venous thrombosis may have a large proportion of patients with lower-extremity trauma and fractures. A recent review article suggests that trauma patients with no additional risk factors for venous thromboembolism are at relatively low risk. \(^{53}\) However, in trauma patients with clinical risk factors, the incidence is high enough to justify both prophylaxis and close surveillance. \(^{54}\) In multiple trauma patients, limited data suggest that intermittent pneumatic compression, warfarin, or low-molecular-weight heparin may be effective. A recent nonrandomized study suggests that low-dose heparin is inadequate prophylaxis in patients with multiple trauma. \(^{55}\) In patients with extensive trauma who have multiple risk factors but who cannot receive other forms of prophylaxis, inferior vena cava filter insertion may be considered, but there are no randomized prospective control studies to verify efficacy. Serial duplex ultrasonography to detect subclinical deep vein thrombosis may also be helpful in these patients. \(^{56}\)

In patients with acute spinal cord injury, the venographic incidence of deep venous thrombosis has been reported as 18% to 90%, with an average incidence of 38% (Table III). Pulmonary embolism occurs in about 5% of patients following paralysis due to acute spinal cord injury, and the period of greatest risk appears to be during the first 2 weeks following the injury. \(^{57,58}\) Death from pulmonary embolism is unusual 3 months or more after injury. Low-dose heparin appears to be relatively ineffective in patients with spinal cord injury, whereas low-molecular-weight heparin is clearly efficacious. \(^{57,58}\) Warfarin and intermittent pneumatic compression prophylaxis have not been well studied in these patients but would probably be effective based on their ability to prevent venous thromboembolism in high-risk orthopedic patients. \(^{59}\) (Table III).

CONCLUSIONS

Venous thrombosis and pulmonary embolism are preventable causes of death and morbidity in hospitalized patients. The loss of productive lives and the economic burden imposed by dealing with the consequences of venous thromboembolism in surviving patients demand attention. A wide variety of effective prophylactic methods are available to prevent venous thromboembolism. These methods have been tested in numerous randomized clinical trials of immaculate scientific design. Whether these trials are considered singly or in aggregate in the form of overview analyses, the inescapable conclusion is that the prophylactic strategies considered in this review prevent morbidity and mortality associated with venous thromboembolism. Individual patients can be assigned a level of risk for venous thromboembolism based on clinical risk factors. The choice of prophylactic method is based on the level of risk, the potential for side effects and complications, and the overall costs. With the wide variety of proven prophylactic methods, the approach can be readily tailored to individual patients' needs. No patient at significant risk for venous thromboembolism should be left unprotected.

REFERENCES


