Clinical Assessment of Venous Thromboembolic Risk in Surgical Patients

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Despite the availability of effective prophylactic methods, postoperative venous thromboembolism still represents an important problem due to its significant morbidity and mortality. What are the reasons for this apparent contradiction? First, different surveys conducted in the United States and Europe show a low implementation of prophylaxis among general surgeons. Second, prophylaxis is usually restricted to a short perioperative period, around 7 days, while the risk for developing deep vein thrombosis (DVT) and pulmonary embolism (PE) may be present before the operation and persist for several weeks after surgery.

A variety of factors predispose to venous thromboembolism, including deficiencies of antithrombin III, proteins C and S, and dysfibrinogenemia. More frequently, acquired factors such as age, obesity, varicose veins, and neoplasms, increase the potential of having DVT and PE. The list of known risk factors is considerable. Recognizing the factors occurring in a given patient is necessary to assess the potential thrombotic risk and select the best prophylactic regimen.

Conclusions drawn at the National Institutes of Health (NIH) Consensus Development Conference, “Prevention of Venous Thrombosis and Pulmonary Embolism,” indicated the need to tailor prophylaxis for the prevention of venous thromboembolism according to the patient’s disease and degree of risk. This conclusion seems to be an obvious statement of current clinical practice in the prevention of DVT and PE. The establishment of DVT risk factor assessment programs for routine use in surgical populations at the time of hospital admission is not yet in widespread use in the United States.

In 1988 we began a DVT Risk Assessment Program in our Department of Surgery, recording the presence of factors related to venous thromboembolism risk, to obtain a score index of low, moderate, or high risk that could be used by the attending physician, to determine the prophylactic action warranted for a particular patient. The primary aims of this study were, first, to evaluate how well our proposed risk assessment rating system correlates with other similar schemes proposed in the literature (Nicolaides and Irving 1975; Janssen et al. 1987; Anderson 1988), and second, to estimate the DVT risk distribution and prophylaxis implementation in the surgical population of a 150 bed hospital that could represent the average suburban and community hospital.

PATIENTS AND METHODS

The study population included 538 patients admitted to the Glenbrook Hospital to undergo surgery during the period of January 1989 to November 1989. The surgical categories included general, urologic, orthopedic, gynecologic, and head and neck. At the time of hospital admission, each patient was interviewed, and, by using the 20 risk factors on the risk assessment worksheet shown in Figure 1, a total risk score was computed using each rating scheme.

It should be noted that within the predisposing conditions, several fields are potentially hidden from the patient, not in the patient’s record, and hidden from the
THROMBOSIS RISK FACTOR ASSESSMENT

Due within 24 hours of admission.
Please fill in the information below.

Name_________________________________________ Age______ Sex____
Diagnosis______________________________________
Type of therapy planned________________________

Please, check all pertinent fields (Each factor has a value of 1 unless otherwise noted).

_ Age 41 to 60 years (1 factor)
_ Age 61 to 70 years (2 factors)
_ Age over 70 years (3 factors)
_ Planned operation over 2 hours
_ History of DVT/PE (3 factors)
_ Leg edema, ulcers, stasis
_ Sepsis
_ Varicose veins
_ Estrogen or other hormone
_ Malignancy
_ Past immobilization (>72hrs)
_ Cardiovascular disease
_ Trauma
_ History of fracture
_ Obesity (>20% ideal body weight) TOTAL RISK FACTORS____

RISK GROUPS

LOW RISK (0-1 Factors)  MODERATE RISK (2-4 Factors)  HIGH RISK (>4 factors)

Please check the modality(s) chosen from the list and sign/date.

_ Graduated elastic stockings (GEC)  _ Other
_ GEC plus sequential intermittent compression (GEC-SIC)  _ No prophylaxis
_ Low dose heparin (LDH)
_ Warfarin

Examining Physician’s signature ___________________________ Date________

FIG. 1. Risk assessment worksheet used in this study.
interviewer. One such factor is history of DVT or PE. In an attempt to enhance the ability of this system to register this parameter, indirect fields have been included, indicating either symptoms that are related to post-thrombotic syndrome or previous periods in the patient’s history that could be considered higher risk periods for thromboembolic disease. These fields include previous major surgery, past immobilization (more than 72 hours), and leg edema, ulcers, or stasis.

Age was included in one of three categories, 41 to 60 years (1 factor), 61 to 70 years (2 factors), and over 70 years (3 factors). History of DVT or PE was included with a weighting of three. Otherwise, the factors were counted with a value of one.

Using the 20 risk factors on the risk factor assessment form, a total risk score was computed for each patient using our rating scheme. The categorization into low-, moderate-, and high-risk categories was subsequently accomplished based on the total risk score identified. Low risk was defined as 1 or less, moderate as 2 to 4 and high risk as a total score of 5 or more. Apart from the total score, the modality of prophylaxis chosen by the attending physician was registered in the worksheet (Fig. 1).

The spreadsheet package Lotus 1-2-3 was used to enter the patient data into the computer. Statistical analysis consisted of calculating the Pearson correlation coefficients between the risk scores computed using our scheme and the other three schemes. This was carried out using the SPSS/PC + package on a Zenith 386 microcomputer.

**RESULTS**

Following tabulation of risk parameters for each of the 538 patients, and after calculating the total score, patients were distributed into three different risk categories (Table 1).

Of the 538 patients assessed, 34.5% were found to be at low, 48.5% at moderate, and 17% at high risk. It is noteworthy that this distribution is the same whether one uses a weighting factor of 3 or 5 for history of DVT or PE.

The Pearson correlation coefficients between the risk scores computed using our scheme and the other three were as follows: Nicolaides: 0.8162, Janssen: 0.6439, Anderson: 0.8960 (Table 2).

The risk factors were ordered according to their frequencies of occurrence in the given patient sample and were entered into the model starting with the most frequently occurring risk factor. In this ordering, account

<table>
<thead>
<tr>
<th>Group</th>
<th>No.</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Low risk</td>
<td>185</td>
<td>34.3%</td>
</tr>
<tr>
<td>Moderate risk</td>
<td>261</td>
<td>48.5%</td>
</tr>
<tr>
<td>High risk</td>
<td>92</td>
<td>17.2%</td>
</tr>
<tr>
<td>Total</td>
<td>538</td>
<td>100%</td>
</tr>
</tbody>
</table>

was taken of the weights different from 0-1 weights assigned to the age and history of DVT or PE variables. For example, the frequencies for the four age groups were: 222 (< 41 years, weight = 0), 151 (41 to 60 years, weight = 1), 90 (61 to 70 years, weight = 2), and 75 (more than 70 years, weight = 3), giving a total weighted frequency of 556 for 538 patients, or a relative frequency of 103.3%. Similarly, there were 26 patients with a previous history of thrombosis (using a weight of 3) giving a weighted frequency of 78 of 538, or a relative frequency of 14.5%. Table 3 shows the order in which the risk factors were entered, their weighted relative frequencies, and the correlation coefficients obtained with other rating schemes using those risk factors in our rating scheme.

Patients were cross-classified according to their predicted length of operation (less than 2 hours, more than 2 hours) and the actual length of operation was similarly recorded. Only 21 of 509 patients were predicted to have an operation longer than 2 hours (4.1%), but 103 (20.2%) did have operations longer than 2 hours (Table 4).

Overall, 200 patients (37.2%) received prophylactic regimens. Among the three risk categories, prophylaxis was applied in 20 (10%) of the low-risk cases, in 110 (42.1%) of the moderate-risk cases, and in 70 (76%) of the high-risk cases (Fig. 2).

The prophylactic modalities preferred by our physicians were the combination of graduated elastic compression stockings and sequential intermittent pneumatic compression, used alone or in combination with low-dose subcutaneous heparin (5000 IU twice daily). In some cases this subcutaneous heparin was used alone (Table 5).

**TABLE 1. Risk Category Classification**

<table>
<thead>
<tr>
<th>Group</th>
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</tr>
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</tr>
<tr>
<td>Total</td>
<td>538</td>
<td>100%</td>
</tr>
</tbody>
</table>

**TABLE 2. Correlation Coefficients Between Our and Other Risk Assessment Systems**

<table>
<thead>
<tr>
<th>Risk Assessment</th>
<th>Correlation</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nicolaides and Irving&lt;sup&gt;10&lt;/sup&gt; 1975</td>
<td>0.8162</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Anderson&lt;sup&gt;12&lt;/sup&gt; 1988</td>
<td>0.8960</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Janssen et al&lt;sup&gt;11&lt;/sup&gt; 1987</td>
<td>0.6439</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>
TABLE 3. Risk Factor Distribution

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Relative Frequency (%)</th>
<th>Correlations</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Anderson</td>
<td>Nicolaides and Irving</td>
<td>Janssen et al</td>
</tr>
<tr>
<td>Age</td>
<td>103.3*</td>
<td>0.8011</td>
<td>0.7196</td>
<td>0.2886</td>
</tr>
<tr>
<td>Previous surgery</td>
<td>63.6</td>
<td>0.7610</td>
<td>0.6706</td>
<td>0.2961</td>
</tr>
<tr>
<td>Obesity</td>
<td>16.4</td>
<td>0.8066</td>
<td>0.6468</td>
<td>0.3534</td>
</tr>
<tr>
<td>History of DVT</td>
<td>14.5</td>
<td>0.8336</td>
<td>0.7739</td>
<td>0.4531</td>
</tr>
<tr>
<td>History of immobilization</td>
<td>8.6</td>
<td>0.8332</td>
<td>0.7786</td>
<td>0.4673</td>
</tr>
<tr>
<td>Malignancy</td>
<td>8.4</td>
<td>0.8606</td>
<td>0.7663</td>
<td>0.5019</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>8.2</td>
<td>0.8815</td>
<td>0.7729</td>
<td>0.5453</td>
</tr>
<tr>
<td>Varicose veins</td>
<td>7.8</td>
<td>0.8681</td>
<td>0.8037</td>
<td>0.5825</td>
</tr>
<tr>
<td>History of trauma</td>
<td>6.3</td>
<td>0.8679</td>
<td>0.8098</td>
<td>0.5831</td>
</tr>
<tr>
<td>Inflammatory bowel disease</td>
<td>5.8</td>
<td>0.8644</td>
<td>0.8027</td>
<td>0.5819</td>
</tr>
<tr>
<td>Estrogen therapy</td>
<td>5.6</td>
<td>0.8726</td>
<td>0.7972</td>
<td>0.6241</td>
</tr>
<tr>
<td>Leg edema</td>
<td>4.8</td>
<td>0.8712</td>
<td>0.8057</td>
<td>0.6314</td>
</tr>
<tr>
<td>Length of operation (&gt;2 hr)</td>
<td>3.9</td>
<td>0.8822</td>
<td>0.8152</td>
<td>0.6285</td>
</tr>
<tr>
<td>Trauma</td>
<td>3.2</td>
<td>0.8898</td>
<td>0.8104</td>
<td>0.6435</td>
</tr>
<tr>
<td>Stroke</td>
<td>2.2</td>
<td>0.8963</td>
<td>0.8124</td>
<td>0.6344</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>1.5</td>
<td>0.8939</td>
<td>0.8112</td>
<td>0.6302</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>0.9</td>
<td>0.8961</td>
<td>0.8117</td>
<td>0.6402</td>
</tr>
<tr>
<td>Sepsis</td>
<td>0.9</td>
<td>0.8945</td>
<td>0.8170</td>
<td>0.6456</td>
</tr>
<tr>
<td>Nephrotic syndrome</td>
<td>0.4</td>
<td>0.8955</td>
<td>0.8160</td>
<td>0.6439</td>
</tr>
<tr>
<td>Lupus anticoagulant</td>
<td>0.2</td>
<td>0.8960</td>
<td>0.8162</td>
<td>0.6439</td>
</tr>
</tbody>
</table>

*See text.

DISCUSSION

Different indices have been reported in the literature to predict the risk for developing postoperative DVT in different surgical groups. The application of these indices should allow us to restrict prophylaxis to the patients at risk and minimize cost and risks of some prophylactic modalities. Most of those predictive indices are calculated from equations combining clinical factors and laboratory results. The need for special coagulation or fibrinolysis studies to obtain such indices has probably prevented them from being widely ac-
cepted, because, as Ruckley pointed out, “a policy for selection of prophylaxis which fits automatically into the ward routine is much more likely to be consistently and therefore successfully applied than one which requires a decision for each patient.” He also suggested that simple

![Patients with prophylaxis (%)](image)

FIG. 2. Implementation of prophylaxis according to risk category.
TABLE 5. Prophylactic Modalities Used in 200 Patients

<table>
<thead>
<tr>
<th>Modalities*</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEC-SIC</td>
<td>117</td>
<td>21.8</td>
</tr>
<tr>
<td>GEC</td>
<td>54</td>
<td>10.0</td>
</tr>
<tr>
<td>GEC-SIC-LDH</td>
<td>24</td>
<td>4.5</td>
</tr>
<tr>
<td>LDH</td>
<td>5</td>
<td>0.9</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>37.2</td>
</tr>
</tbody>
</table>

*GEC: graduated elastic compression; SIC: sequential intermittent compression; LDH: low-dose heparin.

studies with objective diagnostic techniques indicate that surgical patients with a past DVT have a threefold increased incidence of thrombosis following abdominal surgery compared with the same population without a history of DVT.13 The basis of the significance of this factor has several potential explanations. First, venous thrombosis generates scarring of the intimal lining of the vein, which produces a nidus for future clot formation.28 In addition, after a DVT, there is valvular destruction resulting in venous pump deterioration with significant blood stagnation in the lower limbs.32,33 Finally, fibrinolytic activity is depressed in patients with post-thrombotic syndrome compared with the normal population.34 Therefore in patients with a history of DVT, the potential abnormalities encompass all three components of Virchow’s triad, which provides some explanation of the significance of this factor in determining a risk index for DVT.

Another significant factor predisposing to venous thrombosis is venous stasis that can result from immobilization.5,35-37 This leads to slowing of blood flow, and venous dilatation, which are two important components of Virchow’s triad. In this regard, immobility is one of the most important risk factors and its effects can extend not only through the hospital stay, but also before hospital admission and after hospital discharge.5,28

Other conditions correlating to increased risk for DVT and PE include malignancy, varicose veins, trauma, obesity, severity and length of operation, pregnancy, infection, inflammatory bowel disease, myocardial infarction, congestive heart failure, stroke, estrogen, lupus erythematosus, and various hypercoagulable states.54,55

One of the objectives of this study was to draw correlations with other proposed schemes in the literature.10-12 This comparison represents a measurement of “internal” agreement between different rating methods when a pure (nonprophylaxis) external outcome is not available.

The total risk scores for the different rating schemes have the following interpretations: for the Anderson scheme, the total number of risk factors; for the Nicolaides scheme, the probability of developing DVT; and for the Janssen model, the relative risk of developing DVT in comparison to that of the general 35-year-old population. Of course, not every scheme used all 20 risk factors and the Nicolaides10 and Janssen11 models used risk factors that were not available on our form and therefore had to be separately obtained.

Of the statistical analysis comparing our model to other risk assessment systems, the correlations are clearly significant because of the large number of patients on
considered, age was clearly the most significant factor in drawing correlations with other methods of risk assessment.

A point of interest was the accuracy of prediction by the surgeon performing the operation of the length of the operation. From Table 4 we see that only 21 of the 509 patients were predicted to have an operation longer than 2 hours, but in fact 103 did, that is, five times as many. Thus, there seems to be a consistent underestimation of the time required to perform the operation.

Although less than 38% of the global population studied received prophylactic regimens, it is interesting that this implementation increased dramatically to 76% for the high-risk group, which represents 17% of the 538 patients (Fig. 2). Overall, the preferred prophylactic modalities were mechanical—sequential intermittent pneumatic compression and graduated elastic stockings—as opposed to the pharmacologic and combined mechanical-pharmacologic modalities (Table 5). These results could reflect certain reluctance toward anticoagulants in this country, in contrast to Europe, where heparin and dextran are used more by surgeons. The fear of bleeding complications could be the reason for this "safe" approach. Because the NIH Consensus Conference recommended combined regimens or adjusted doses of heparin for the higher risk patients, it is important to identify those groups and restrict the "aggressive" modalities of prophylaxis to patients in whom it is potentially cost-effective. This could be achieved by using any system providing reliable information about the potential for developing DVT. In this regard, it is evident that awareness of the problem, knowledge of risk assessment, and appropriate use of prophylaxis require continuing education and clinical vigilance.

Finally, we believe that more work is necessary to correlate the level of risk using this scoring system with the actual occurrence of thromboembolism. The accomplishment of this goal is a difficult task due to the occult nature of thromboembolic events. Accurate diagnosis requires extensive and, in many cases, invasive studies in every patient to identify all thrombotic cases. Nevertheless, the next step in the risk assessment area should correlate the level of risk using this scoring system with the objective documentation of DVT in a selected group of patients. This should result in a validation and refinement of this risk assessment model that may encourage greater clinical implementation of prophylaxis tailored to the degree of patient risk.

**SUMMARY**

Prophylaxis against postoperative venous thromboembolism should be tailored according to the patient's
GLENBROOK HOSPITAL - DEPARTMENT OF SURGERY
THROMBOSIS RISK FACTOR ASSESSMENT

Due within 24 hours of admission.
Please fill in information below.
Name__________________ Age____ Sex__________
Diagnosis______________ Admission Elective or Emergency
Type of surgery planned________________________

Please check all pertinent factors (Each risk factor has value of 1 unless otherwise noted.)

__Age 41 to 60 years (1 factor)   __Pelvic surgery or total joint replacement
__Age 61 to 70 years (2 factors)  __Confining travel, flight/auto
__Age over 70 years (3 factors)   __>4 hours within week of admission
__Anticipated bed confinement over 72 hours  __History of pelvic or long bone fracture
__History of DVT/PE (3 factors)  __Leg edema, ulcers, stasis
__Varicose veins  __Malignancy
__Obesity (>20% of ideal body weight)  __Pregnancy or postpartum (<1 month)
__History of previous major surgery  __Inflammatory bowel disease
__Previous immobilization (>72 hours)  __Severe infection
__MI  __Hormone Therapy
__CHF  Name__________________
__Stroke  Dosage__________________
__Crystalloid infusion (>5 liters/24 hrs)  __Hypercoagulable states
__Severe COPD  Congenital__________________
__Trauma  Acquired__________________
__Planned operation over 2 hours  __Other__________________

TOTAL RISK FACTORS______

RISK GROUPS
LOW RISK
(1 Factor)
RECOMMENDED MODALITIES
TED Stockings Early ambulation

MODERATE RISK
(2-4 Factors)
TED + SCD OR Heparin

HIGH RISK
(More than 4 Factors)
TED + SCD plus selected pharmaceutical (Heparin or Warfarin)

Please check the modality(s) chosen from the list below and sign/date.

__TED stockings
__TED plus SCD
__Heparin (Regimen:___________)
__Warfarin (Regimen:___________)

__Other
__No prophylaxis
__Suspected DVT, perform diagnostics

Contraindication to anticoagulants? Yes or No
If yes, explain. ________________________________________

Experiencing Physician's Signature________________________ Date__________

FIG. 3. Revised worksheet for the assessment of venous thromboembolic risk in surgical patients.
level of risk. However, risk assessment is not yet in widespread use in surgical practice. In this study, 538 general surgical patients were prospectively assessed based on a scoring system containing 20 risk factors. Depending on the total risk factor score, the patients were grouped into low (0 to 1, 34.5%), moderate (2 to 4, 48.5%), or high risk (more than 4, 17.2%) categories. Statistically significant (p < 0.0001) correlation was found between our results and those of three existing risk assessment systems. Overall, of the 538 patients, 37.2% received prophylaxis; 10%, 42.1%, and 76% received prophylaxis in the low-, moderate-, and high-risk categories, respectively. Mechanical prophylactic modalities (graduated elastic compression and sequential intermittent compression) were preferred over pharmacologic modalities. These results suggest that implementation of prophylaxis remains underutilized despite published reports, including NIH guidelines. Our results indicate that the majority of surgical patients seen in this suburban hospital have two or more risk factors for developing venous thromboembolism.

ACKNOWLEDGMENTS

We acknowledge the help of Stella Caprini, Pamela Adams, Warren Yu, and Steve Rudnick for their assistance in the preparation of this manuscript.

REFERENCES

30. Prescott RJ, DB Jones, C Vasisitie, JT Henderson, CV Ruckley:


