
Patients undergoing ACL reconstruction at risk for DVT, but may not show symptoms. The authors reported that 47% are at risk for DVT for patients older than 30 following arthroscopic ACL surgery. The study identified a 21% rate of deep venous thrombosis in patients after double-bundle arthroscopic ACL reconstruction. The incidence of DVT was significantly higher in patients over 30. Reason’s for such high incidence included special DVT screening methods and that pharmacological DVT prophylaxis was not used. “Therefore, after common arthroscopic surgery, DVT may occur more frequently than we previously assumed”, Dr. Inoue said in presenting his findings at the 2007 International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine Congress.


Two common prophylactic measures to prevent deep vein thrombosis (DVT) in patients after orthopedic lower limb surgeries are pneumatic foot and calf compression and antithrombotic treatment. These preventive measures differ in their mechanisms of operation. Antithrombotic agents are aimed to minimize the risk of clot formation, whereas pneumatic foot and calf compression therapy prevents venous stasis, which is a primary factor leading to thrombus formation in patients with leg trauma. DVT, however, is not the only consequence of patient immobility and venous stasis. Additional sequelae of venous stasis include lower limb swelling and pain resulting from the increase in venous pressures and change of normal compartmental circulatory pressures. We therefore hypothesized in the present study that antithrombotic treatment alone is not as effective as combined with pneumatic foot compression in reducing limb swelling and pain. Forty-eight patients after total knee arthroplasty participated in this randomized, controlled study. Low-molecular-weight heparin was the prophylactic measure used for the control group, whereas the pneumatic compression group received low-molecular-weight heparin and foot compression therapy for approximately 7 days after surgery. Lower limb swelling and pain were significantly reduced for the foot compression group in relation to the control group. Ultrasound and venography demonstrated no significant DVT in either group. We conclude that foot compression therapy is an important prophylactic addition to antithrombotic treatment in overcoming the hazardous clinical implications of venous stasis.


The objective of this study was to investigate the effect of continuous long-term application of a combined cooling and compression (CC) system with traditional ICE on postoperative swelling, ROM, pain, consumption of analgesics, and return of function after ACL reconstruction. The ICE Group received ice bags postoperatively; the CC group was provided with the cold-compression device during the 14-day hospital stay. Girth, ROM pain score (visual analog scale), and consumption of analgesics were determined on postoperative days 1, 2, 3, 6, 14, and 28. In the CC group, significantly less swelling was observed (P < 0.035). These patients also reported less pain and had a significantly reduced consumption of analgesics (P < 0.04). On all examination days, ROM in the CC group was up to 17% greater than in the ICE group (P < 0.02). The functional knee score was significantly increased in the CC group (P = 0.025). The results from our study document the advantages of continuous cold-compression therapy over cold alone following ACL Reconstruction.
Thromboembolic events lower in shoulder than THR and THA
But a larger percentage of shoulder arthroplasty-related events involve PE. Prophylaxis may reduce DVT, PE frequency.

By Gina Brockenbrough

April 2006

CHICAGO — Researchers have identified the prevalence and potential risk factors associated with thromboembolic events following shoulder arthroplasty.

Robert G. Marx, MD, and colleagues at the Hospital for Special Surgery in New York, reviewed the records of nearly 14,000 total shoulder and hemi-arthroplasty patients. They found a deep vein thrombosis (DVT) rate of 5 per 1000 procedures and a pulmonary embolism (PE) rate of 2.3 per 1000 procedures. Patients admitted for trauma, who had an older age or a previous cancer diagnosis had a higher risk for such events following surgery.

The researchers also compared the frequency of thromboembolic events among shoulder arthroplasty patients to the frequency among total hip and knee patients.

"While the frequency of DVT is about three- to five-times lower among total shoulder and hemi-arthroplasty patients than in total hip and total knee patients, the frequency of PE was just 2.5-times lower," said Marx, who presented the study results here at the American Academy of Orthopaedic Surgeons 73rd Annual Meeting.

Marx cautioned that the study included patients admitted between 1985 and 2003. Therefore the findings may not reflect the effects of current prophylaxis measures. "It should also be noted that during the time period of this study, use of DVT and PE prophylaxis was routine among the total hips and knees, but not among the shoulders," he said.

For the study, Marx and colleagues gathered information on over 300,000 arthroplasty patients from the New York State Department of Health’s State-wide Planning and Research Cooperative System (SPARCS) database. They then reviewed the records of patients treated with the following procedures: total shoulder arthroplasty (TSA), shoulder hemi-arthroplasty (SHA), total knee arthroplasty (TKA) or total hip arthroplasty (THA). The presence or absence of a specific code number indicated the occurrence of thromboembolic events (ie, DVT or PE).

Among TSA and SHA patients, the researchers identified 69 instances of DVT and 32 instances of PE.

Overall, shoulder patients had a DVT rate of 5 per 1000 procedures — significantly lower than THA and TKA patients. In comparison, THA patients had a DVT rate of 15.7 per 1000 and TKA patients had a rate of 26.9 per 1000.

Additionally, shoulder patients had a lower incidence of PE — 2.3 per 1000 procedures vs. 4.2 per 1000 among THA patients and 4.4 per 1000 among TKA patients, according to the study. However, "The ratio of PE to DVT in shoulder patients was higher than in patients who had THA or TKA ...,” the authors noted in the abstract.

"Although the absolute rates of thromboembolic complications were lower in shoulder procedures ... a larger percentage of these were PE. Perioperative antithrombotic prophylaxis may reduce the frequency of DVT and PE among shoulder arthroplasty patients, particularly among higher risk groups,” they said.

Marx added that the study has limitations. The research relied on the accuracy of information entered into the database. Additionally, "limited information about the location of the thrombus or the use of prophylaxis to prevent DVT or PE,” he said.

For more information:
DEEP-VEIN THROMBOSIS: ADVANCING AWARENESS TO PROTECT PATIENT LIVES

White Paper
Public Health Leadership Conference on Deep-Vein Thrombosis
Washington, D.C. • February 26, 2003

American Public Health Association

“The disconnect between evidence and execution as it relates to DVT prevention amounts to a public health crisis.”

Samuel Z. Goldhaber, M.D., Associate Professor of Medicine, Harvard Medical School
Deep-Vein Thrombosis: Advancing Awareness to Protect Patient Lives

Introduction

Every year, an estimated 200,000 up to 600,000 Americans will suffer from deep-vein thrombosis (DVT) and pulmonary embolism (PE).1,2,3 Deep-vein thrombosis and PE are collectively known as venous thromboembolism (VTE). For the 60,000 to 200,000 individuals who develop PE, their condition will be fatal.1,2 In the United States, more people die each year from PE than motor vehicle accidents, breast cancer or AIDS.3,4,5,6

<table>
<thead>
<tr>
<th>Some Causes of Death in the U.S.</th>
<th>Annual Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary embolism2,3</td>
<td>Up to 200,000</td>
</tr>
<tr>
<td>AIDS4</td>
<td>14,499</td>
</tr>
<tr>
<td>Breast cancer5</td>
<td>40,200</td>
</tr>
<tr>
<td>Highway fatalities6</td>
<td>42,116</td>
</tr>
</tbody>
</table>

Deep-vein thrombosis is a common but under-diagnosed medical condition that occurs when a thrombus (blood clot) forms in one of the large veins, usually in the lower limbs, leading to either partially or completely blocked circulation.1 The condition may result in health complications, such as PE, if not diagnosed and treated in a timely and effective manner. Pulmonary embolism can occur when a fragment of a blood clot breaks loose from the wall of the vein and migrates through the heart to the lungs, where it blocks a pulmonary artery or one of its branches.1 When that clot is large enough to completely block one or more of the vessels that supply the lungs with blood, it can result in sudden death.1

Surprisingly, almost three-quarters (74 percent) of adults have little or no awareness of DVT, according to a national survey conducted on behalf of the American Public Health Association (APHA).7 Of the respondents aware of DVT, more than half (57 percent) were unable to name any common risk factors or pre-existing conditions that could lead to the development of DVT. And, 95 percent of adults surveyed reported that their physician had never discussed this medical condition with them.7

The APHA and the Centers for Disease Control and Prevention (CDC) convened 60 of the nation’s leading medical experts and patient advocates in Washington, D.C. in early 2003. This event, the Public Health Leadership Conference on Deep-Vein Thrombosis, brought into the spotlight the urgency for increased diligence related to prevention on the part of the healthcare community – as well as the need to raise awareness of DVT and its complications among the public.
Conference participants addressed two critical issues: awareness and prevention. Physicians and other healthcare providers must be aware of risk factors and risk stratification. Moreover, they must take more aggressive action in screening patients for risk factors and in prescribing preventive interventions. In the case of prophylaxis with anticoagulants, well-controlled studies have shown that the use of these medications can reduce the risk of DVT and PE by two-thirds.\(^1\) Unfortunately, a study also shows that only about 30 percent of patients at risk for DVT receive this type of prophylaxis.\(^8\) Based on these findings, conference participants also urged the American public to become more aware of DVT, its symptoms, and risk factors.

This White Paper is based on the initiatives suggested by the participants and attendees at the Public Health Leadership Conference on Deep-Vein Thrombosis. The goal of this communication is to create a better understanding of both the high incidence of DVT and PE and the availability of preventive options for these conditions.
Deep-Vein Thrombosis: Advancing Awareness to Protect Patient Lives

1. Describing Deep-Vein Thrombosis

A deep-vein thrombus (blood clot) is an intravascular deposit that is composed of fibrin and red blood cells with a variable platelet and leukocyte component. Deep-vein thrombosis occurs when a thrombus forms (usually in regions of slow or disturbed blood flow) in one of the large veins, usually in the lower limbs, leading to either partially or completely blocked circulation. The condition may result in health complications, such as fatal PE, if not diagnosed and treated in a timely and effective manner. Pulmonary embolism can occur when a fragment of a blood clot breaks loose from the wall of the vein and migrates to the lungs, where it blocks a pulmonary artery or one of its branches. When that clot is large enough to completely block one or more vessels that supply the lungs with blood, it can result in sudden death. Deep-vein thrombosis and PE are collectively known as venous thromboembolism (VTE).

2. Outlining the Scope of the Problem

Published studies estimate that the annual incidence of DVT and PE ranges from 200,000 up to 600,000 cases, and may contribute to 60,000 to 200,000 deaths. Many of these deaths can be prevented through routine use of simple preventive measures. Medical experts say that it is critical to warn patients about the risks, and for physicians and other healthcare providers to employ preventive measures.

Venous thromboembolism is the number-one cause of unexpected hospital death, according to Samuel Z. Goldhaber, M.D., of Harvard Medical School, who directs the VTE Research Group at Brigham and Women’s Hospital in Boston. Additionally, Dr. Goldhaber has reconfirmed the finding that VTE is a major national health problem, especially among hospitalized patients.

3. Measuring DVT Awareness

Most Americans are unaware of DVT, its symptoms, and its risk factors, according to a nationwide survey conducted on behalf of the APHA. At the Public Health Leadership Conference on Deep-Vein Thrombosis (“Conference”), Georges C. Benjamin, M.D., F.A.C.P., the Executive Director of the APHA presented key findings.

Conference panelist Rear Admiral Kenneth P. Moritsugu, M.D., M.P.H., Deputy Surgeon General of the United States, stated that DVT is a condition that does not discriminate – it affects young and old, the very fit (e.g., Olympic athletes), as well as public figures, such as former Vice President Dan Quayle. Less than two months after the Conference, acclaimed journalist David Bloom died as a result of VTE while on assignment in Iraq. His death raised awareness and questions among the public about DVT.

“It’s fascinating to us that two-thirds of Americans do not know anything about deep-vein thrombosis. And what’s even more fascinating is that more than half of those individuals who do know about the disease, don’t know what the risk factors are, nor do they know the signs and symptoms.”

Georges Benjamin, M.D., F.A.C.P., Executive Director, APHA
4. Listening to a Silent Epidemic

Fatal PE may be the most common preventable cause of hospital death. “Two-thirds of those individuals who die from PE do so unnecessarily,” maintains Dr. Goldhaber. “Routine use in hospitals of simple, well-established and effective methods of DVT prevention would save the lives of thousands of Americans each year. Unfortunately, however, the management of PE has been characterized by a failure to use preventive measures that are known to be effective.” According to Dr. Goldhaber, the failure to administer preventive measures, or to “prophylax,” is an established practice pattern with significant adverse consequences.

To illustrate that the silent epidemic of DVT remains unacknowledged, a recent study in hospital patients with DVT, known as DVT-FREE, found that 71 percent of patients with DVT did not receive prophylaxis within 30 days prior to diagnosis. Surgical patients were much more likely than nonsurgical patients to receive prophylaxis for this condition. These findings indicate that proven regimens for the prevention of DVT are underutilized. Clinical trials and guidelines for prophylaxis and treatment have progressed further and faster than “real-world” preventive efforts and outpatient therapy. “The disconnect between evidence and execution as it relates to DVT prevention amounts to a public health crisis,” says Dr. Goldhaber.

5. Understanding DVT Risk Factors

The following information summarizes the risks and symptoms for DVT. About half of the time, however, the condition causes no symptoms.1,10

<table>
<thead>
<tr>
<th>WHO IS AT RISK?</th>
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<tbody>
<tr>
<td>Top risk factors and triggering events for DVT:</td>
</tr>
<tr>
<td>• Increasing age</td>
</tr>
<tr>
<td>• Prolonged immobility</td>
</tr>
<tr>
<td>• Stroke</td>
</tr>
<tr>
<td>• Paralysis</td>
</tr>
<tr>
<td>• Previous VTE</td>
</tr>
<tr>
<td>• Cancer and its treatment</td>
</tr>
<tr>
<td>• Major surgery (particularly operations involving the abdomen, pelvis and lower extremities)</td>
</tr>
<tr>
<td>• Respiratory failure</td>
</tr>
<tr>
<td>• Trauma (especially fractures of the pelvis, hip or leg)</td>
</tr>
<tr>
<td>• Obesity</td>
</tr>
<tr>
<td>• Varicose veins</td>
</tr>
<tr>
<td>• Congestive heart failure and myocardial infarction</td>
</tr>
<tr>
<td>• Indwelling central venous catheters</td>
</tr>
<tr>
<td>• Inflammatory bowel disease</td>
</tr>
<tr>
<td>• Nephrotic syndrome</td>
</tr>
<tr>
<td>• Pregnancy, oral contraceptives or post-menopausal hormone replacement</td>
</tr>
<tr>
<td>• Inherited predisposition for clotting11,12</td>
</tr>
</tbody>
</table>
6. Barriers in DVT Prevention

“Deaths resulting from PE, a complication of DVT, can be prevented; however, physicians and other healthcare professionals must routinely assess a person’s risk for the disease in the same way they currently look for risk factors for heart disease,” states APHA’s Georges Benjamin, M.D., F.A.C.P. “Furthermore, we need to encourage more physicians to routinely prophylax patients who may be at risk for DVT.” Yet, assuming knowledge of the risk factors for DVT does not necessarily result in prescribing prophylaxis for this condition. Indeed, participants at the Conference acknowledged that prophylaxis is underused. These experts identified various factors that may create barriers in DVT prevention, including a lack of awareness of DVT risk, perceived differences in risk assessment and perceived risks of bleeding with prophylaxis.

7. Using Available Prophylaxis

Traditional non-pharmacological prophylaxis measures for DVT include early mobilization and the use of sequential compression devices to prevent blood clotting.

However, there are many drugs available to prevent DVT. Anticoagulants, or blood-thinning drugs, work by impairing the body’s normal blood-clotting process, and help to prevent DVT and PE. The most commonly used anticoagulants include unfractionated heparin, low-molecular-weight heparin and warfarin sodium.\textsuperscript{12,14}

8. Moving Forward for DVT Prevention

In addressing DVT awareness and prevention, Conference participants agreed that improving standards of care and enhancing physician training are two key strategies for reducing death and disability due to this condition and its complications. According to Maureen Connors Potter, the Executive Director for disease-specific care certification for the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), one initiative to support these strategies is a new certification program at JCAHO. This approach aims to increase the use of evidence-based medicine as a focal point for disease-specific patient-care services or programs. As a strategy to improve clinical outcomes for patients with DVT, this certification offers a framework for practitioners to implement practice guidelines that impact this condition. However, experts are urging that JCAHO consider a stronger step beyond certification and make DVT prevention a component of accreditation.

<table>
<thead>
<tr>
<th>WHAT ARE THE SYMPTOMS OF DVT AND PE?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neither DVT nor PE may present any obvious symptoms. DVT most commonly occurs in just one leg. Symptoms for both conditions include any or all of the following:</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>DVT of the leg or arm</th>
<th>PE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Tenderness</td>
<td>• Unexplained shortness of breath</td>
</tr>
<tr>
<td>• Pain</td>
<td>• Chest pain or palpitations</td>
</tr>
<tr>
<td>• Swelling</td>
<td>• Anxiety and/or sweating</td>
</tr>
<tr>
<td>• Discoloration or redness\textsuperscript{1,13}</td>
<td>• Coughing up blood</td>
</tr>
</tbody>
</table>
Another initiative, the American Medical Association’s (AMA) Physician Consortium for Performance Measurement, aims to become a leading source for evidence-based performance measures and outcomes reporting tools for physicians. This organization’s secretary-treasurer, John Nelson, M.D., offered the AMA’s assistance in developing an evidence-based performance measure for prevention of DVT.

The Conference identified areas in need of immediate attention for educating the professional community about DVT awareness and prevention. Participants were urged to take action to:

• Create a national coalition to advocate for greater awareness of DVT and PE among healthcare professionals and the general public.
• Enlist the support of medical professional and patient advocacy organizations to make DVT and PE awareness part of their agenda.
• Develop a public awareness campaign to educate consumers about the risk factors, symptoms and prevention measures for DVT.
• Develop communications tools (printed materials, public service announcements, Web sites) to serve as patient educational materials about risk factors, symptoms and prevention for DVT.
• Encourage state medical licensing boards to include DVT and PE prevention in their CME/CE licensing renewal requirements.
• Encourage academic centers to incorporate DVT and PE education into curricula for all medical professionals.
• Close the gap between clinical practice guidelines for DVT prophylaxis and actual practice through the creation and implementation of institutional standards.
• Ask accreditation and “standardization” institutions to ensure that healthcare providers and institutions implement clinical practice guidelines for DVT prevention.
• Encourage the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) to make adherence to DVT prevention guidelines part of its accreditation process.
• Educate policy-makers about cost-effectiveness of DVT and PE prevention and treatment.
• Encourage policy-makers to support reimbursement of DVT and PE prevention and treatment.

9. Reducing the Threat of DVT: Two Paths Toward Change

Conference participants recommended two paths to improve outcomes related to DVT and PE:

Educate the public and healthcare community to raise awareness of DVT and encourage proven methods for preventing deaths from PE.

Public education can take the form of direct-to-consumer outreach or it can involve arming public health organizations with the information necessary to best serve their members. Healthcare professionals can benefit from the best practices of organizations and institutions that have successfully implemented prophylaxis and assessment programs to make best use of preventive therapies, both mechanical and pharmacological.

Work with policy-makers to make DVT a public health priority.

The policy issues include: ensuring appropriate levels of reimbursement for medications available to prevent fatal PEs, motivating adherence to established clinical guidelines, ensuring that treatment and prevention guidelines capture all at-risk populations, and allocating the resources necessary to further investigate ways to prevent long-term complications from DVT and fatalities from PE.
Summary

“Deep-vein thrombosis is preventable,” said Bruce Evatt, M.D., Chief of the Hematologic Diseases branch at the CDC. “We can reduce the risks of its serious and life-threatening complications if we raise education and awareness among the public and urge all healthcare providers to institute standard preventive measures.”

To this end, experts convened at the Public Health Leadership Conference on Deep-Vein Thrombosis to move forward knowledge about this life-threatening condition. This White Paper summarizes the key learnings about DVT and PE with the goal of educating physicians and other healthcare providers, public health advocates and consumers about these conditions. Given the high incidence of DVT and PE, clarifying the risk factors, prophylaxis strategies and policy initiatives to help prevent them is a public health priority.

Understanding the gap in awareness of DVT and PE, as illustrated by the recent national survey, should motivate both professionals and consumers to learn more about these conditions. Moreover, the recognition and acceptance of treatment guidelines and prophylaxis should encourage all physicians and other healthcare providers to prophylax at-risk patients. In doing so, prevention will become an accepted practice and policy.

Advancing awareness of DVT and PE requires physicians and other healthcare providers, as well as patients, to seek more information about these serious conditions. Reviewing symptoms and risk factors, such as those outlined in this paper, will help elevate DVT awareness. For example, whereas surgical patients may be more likely to receive prophylaxis, medical patients with restricted mobility should also be considered at risk for this condition. In addition, greater knowledge is needed about the drugs available to prevent and treat DVT, including anticoagulants. This is critical in the hospital setting, as evidenced by the recent DVT-FREE Registry. The investigators emphasize the need for a new and better understanding of the urgency of providing prophylaxis, “Intensified education is needed to bridge this gap between clinical trial data and everyday clinical practice.”

A Call to Action:

Deep-vein thrombosis and pulmonary embolism constitute major health problems in the United States. Physicians and other healthcare providers, public health advocates and consumers must regard DVT as a life-threatening condition because more people die each year from PE than motor vehicle accidents, breast cancer or AIDS. Furthermore, the need for advancing awareness goes beyond a greater acknowledgement of the incidence of DVT – it must incorporate a better understanding of the preventability of the condition. These constituencies must act now, each in their own sphere of influence, to create a heightened level of awareness and to take more aggressive steps to utilize the existing prophylaxis measures.
Bibliography


Additional sources:


American Academy of Family Physicians
Web site: http://familydoctor.org

American Academy of Orthopedic Surgeons
Web site: http://orthoinfo.aaos.org

American Heart Association
Web site: http://www.americanheart.org
Resources

American College of Chest Physicians
A resource for the improvement in cardiopulmonary health and critical care worldwide comprised of medical and allied health professionals who specialize in diseases of the chest.
3300 Dundee Road
Northbrook, IL 60062-2348
Phone: (800) 343-2227
Fax: (847) 498-5460
http://www.chestnet.org

Centers for Disease Control and Prevention
The lead federal agency charged with the promotion of health and quality of life by preventing and controlling disease, injury and disability.
1600 Clifton Road
Atlanta, GA 30333
Phone: (404) 639-3311
http://www.cdc.gov

American Thrombosis Association
A nonprofit organization dedicated to education for the prevention and treatment of thrombosis.
P.O. Box 6494
Denver, CO 80206-0494
Phone: (303) 384-9239
Fax: (303) 384-9254
http://www.bloodclot.org

Council for Leadership on Thrombosis Awareness and Management
A group of healthcare professionals and educators committed to raising public and healthcare provider awareness of the risks of deep-vein thrombosis.
Major initiatives: DVT-FREE National Screening Program
ClotAlert™ Resource Center
1-800-CLOT-FREE
Public Health Leadership Conference on Deep-Vein Thrombosis

Speakers

GEORGES BENJAMIN, MD, FACP
Executive Director
American Public Health Association (APHA)

SALLY O. CRUDDER, RN
Deputy Chief, Hematologic Diseases Branch
Centers for Disease Control and Prevention (CDC)

MIRANDA FOWLER
DVT patient

RITA MUNLEY GALLAGHER, PhD, RN
Senior Policy Fellow
American Nurses Association (ANA)

SAMUEL Z. GOLDBERG, MD
Associate Professor of Medicine, Harvard Medical School
Director, Venous Thromboembolism Research Group and
Director, Anticoagulation Service at Brigham and Women’s Hospital
Co-chair, Council for Leadership on Thrombosis Awareness and Management (CLOT)

REAR ADMIRAL KENNETH MORITSUGU, MD, MPH
Deputy Surgeon General of the United States
U.S. Department of Health and Human Services

JOHN C. NELSON, MD, MPH, FACOG, FACPM
Secretary-Treasurer
American Medical Association (AMA)

MAUREEN CONNORS POTTER, MS, RN
Executive Director, Disease-Specific Care Certification
Joint Commission on Accreditation of Healthcare Organizations (JCAHO)

VICTOR F. TAPSON, MD
Associate Professor of Medicine, Pulmonary and Critical Care Division
Duke University Medical Center
Representative of the American College of Chest Physicians (ACCP)
Public Health Leadership Conference on Deep-Vein Thrombosis

Participants

Russell Rayman, M D
Executive Director
Aerospace Medical Association

Mike Reynolds
Executive Director
Airhealth.org

George Taler, M D
Past President
American Academy of Home Care Physicians

Ralph Marino, M D
Member
American Academy of Physical Rehabilitation and Medicine

Len Lichtenfeld, M D, FACP
Medical Editor
American Cancer Society

Sydney Parker, PhD
Vice President, Health & Science Policy
American College of Chest Physicians

William C. Dalsey, M D
Co-chair, Clinical Policies Committee
American College of Emergency Physicians

Craig M. Kessler, M D
American College of Physicians Fellow
American College of Physicians-American Society of Internal Medicine

Morgan Downey
Executive Director and CEO
American Obesity Association

Anne Burns
Director Practice Development and Research
American Pharmaceutical Association

Kitty Dana
Associate Executive Director and COO
American Public Health Association

David Fouse
Director of Communications
American Public Health Association

Mo M ayrides
Director of Policy and Practice
American Society of Hematology

Dorothy Adcock, M D
President
American Thrombosis Association

Gordon Ens
Board Member
American Thrombosis Association

Brand Marketing and Communications
Aventis

James M untz, M D
Associate Professor
Baylor College of Medicine

Nils Kucher, M D
Research Fellow
Brigham and Women's Hospital

Ruth B. Morrison, RN, BSN, CVN
Clinical Research Coordinator Venous Thromboembolism Research Group
Brigham and Women's Hospital

James B. Groce, III, PharmD, CACP
Associate Professor of Pharmacy
Campbell University School of Pharmacy

Richard Friedman, M D
Medical Director
Charleston Orthopaedic Associates

Franklin Michota, Jr., M D
Section Head, Hospital and Perioperative Medicine
The Cleveland Clinic Foundation

Andra James, M D, M PH
Assistant Professor of Obstetrics and Gynecology
Duke University

Thomas Ortel, PhD, M D
Assistant Professor
Med-Hematology, School of Medicine
Duke University

Kenneth V. Leeper, Jr., M D
Assistant Professor of Medicine
Emory University School of Medicine

John Heit, M D
Associate Professor of Medicine
The Mayo Clinic

M ary Phelps, RN
Study Coordinator
The Mayo Clinic

Marilyn Manco-Johnson, M D
Director
Mountain States Regional Hemophilia & Thrombosis Center

Carol Vreim
Dep. Director, Division of Lung Diseases
National Heart, Lung & Blood Institute

McDonald Home, M D
Senior Clinical Investigator
National Institutes of Health

Richard Chang, M D
Chief of Special Procedures, Radiology
National Institutes of Health

Laurie Young, PhD
Executive Director
OWL: Older Women's League

Charles Pollack, Jr., M D
Chairman, Dept. of Emergency Medicine
Pennsylvania Hospital

Claire Philipp, M D
Director of Thrombosis Center and Associate Professor of Medicine
Robert Wood Johnson Medical School

Sarah Gevers
Communications Manager
Society for Women's Health Research

Geno J. M erli, M D
Director, Division of Internal Medicine
Thomas Jefferson University Hospital

Deborah O'ker Smith
Founder
Thrombophilia Support Online

Elizabeth Hellman, M S
Genetic Counselor
M aternal-Fetal M edicine
University of Kansas Medical Center-

Stephan M oll, M D
Assistant Professor of Medicine, Hematology
University of North Carolina at Chapel Hill School of Medicine

Jeanette Wedsworth
Physician's Assistant
University of North Carolina at Chapel Hill School of Medicine

Judith Andersen, M D
Affiliated Internist, Karmanos Cancer Institute

Wayne State University, Detroit Medical Center
Best Practices

Preventing
Deep Vein Thrombosis
and Pulmonary Embolism

A Practical Guide to Evaluation
and Improvement

By

Frederick A. Anderson, Jr, PhD
Research Professor of Surgery
Director, Center for Outcomes Research
University of Massachusetts Medical Center

Anne-Marie Audet, MD, MSc, FACP
Medical Director for Quality Improvement
Massachusetts Peer Review Organization

www.dvt.org
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Case study author and editor, Ann G. Forcier BA

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Robert Abel PhD, Project Coordinator, Texas Medical Foundation, Austin TX
Kathleen Blandford, Vice President, Quality Improvement, VHA of New Jersey
Cindy Flaherty RN, Quality Improvement Manager, UMass Medical Center, Worcester MA
Ruth Freed PhD, RN, Performance Improvement Coordinator, Nebraska Methodist Health Systems, Omaha NB
Samuel Goldhaber MD, Associate Professor of Medicine, Division of Cardiovascular Medicine, Brigham and Women’s Hospital, Boston MA
Elaine Jacobson, Peterborough NH
Lois Joch PharmD, Clinical Resource Coordinator, Kettering Medical Center, Kettering OH
Margaret M. Knudson MD, University of California at San Francisco
Donna MacPherson RN, Cardiovascular Division, Brigham and Women’s Hospital, Boston MA
Tony Piskac MD, The Sunderbruch Corp, Lincoln NB
Paul Plesk, Paul E. Plesk & Associates, Roswell GA
Marti Trudeau RN, MPA, Clinical Project Manager, Peer Review Systems, Westerville OH
H. Brownell Wheeler MD, Harry Haidak Distinguished Professor, Department of Surgery, University of Massachusetts Medical Center, Worcester MA.

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Section 1
Venous thromboembolism - the need for prophylaxis

One of the most common causes of death in the hospitalized patient is pulmonary embolism (PE). Routine autopsies estimate that from 10 to 25 percent of all deaths in hospital involve emboli in the lung, many of which are extensive enough to be considered as having caused the death of the patient. In addition, some patients suddenly found dead in bed at home are also thought to be victims of massive, unforeseen PE.

While many of these individuals may have had a terminal illness leading to embolism, a significant number of deaths occur in patients who had comparatively minor ailments and who might otherwise have lived normal and healthy lives.

Death and morbidity
It is estimated that one in 100 patients admitted to a hospital dies because of PE. It appears possible than more than one-half of these at-risk patients could be saved if effective prophylaxis was used. For example, patients undergoing major operations without receiving prophylaxis are put at risk of fatal PE and stand an even greater risk of morbidity from related conditions.

In more than 90 percent of cases of PE, the thrombosis originates in the deep veins of the legs. Deep vein thrombosis (DVT) is itself a distressing but often avoidable condition that leads to long-term complications such as the post-phlebitic syndrome and chronic leg ulcers in a large proportion of patients who have proximal vein thrombosis.

“Pulmonary embolism remains the most common preventable cause of death in hospital”
Morrell MT and Dunnill MS (1968) Br J Surg 55, 347-352
Table 1.1  Patients at risk of venous thromboembolism

| Trauma patients | • Accidental trauma  
|                 | • Surgical patients  
|                 |   orthopaedic surgery (hips and knees)  
|                 |   major surgery lasting longer than 30 minutes |
| Additional risk factors | • Age (risk rises steadily from age 40)  
|                          | • Obesity  
|                          | • Malignancy  
|                          | • History of DVT or PE  
|                          | • Immobilization (bed rest, paralysis of legs, plaster casts)  
|                          | • Pregnancy and puerperium  
|                          | • Oral contraceptive use  
|                          | • Extensive dissection at surgery |
| Clinical disorders predisposing to venous thrombosis | • Varicose veins  
|                                                       | • Cardiac problems (e.g. cardiac failure and myocardial infarction)  
|                                                       | • Stroke  
|                                                       | • Nephrotic syndrome  
|                                                       | • Thrombocytosis  
|                                                       | • Primary proliferative polycythaemia  
|                                                       | • Systemic lupus erythematous  
|                                                       | • Infection |

Table 1.2  Venous thromboembolism - a serious and common problem that can and should be prevented

| A serious problem | • 80% of PE occur without signs  
|                  | • 2/3 of deaths occur within 30 minutes |
| A common problem | • One in 100 hospitalized patients dies of PE |
| Can be prevented | • Half of PE, 2/3 of DVT in review of 16,000 patients |
| Should be prevented | • NIH recommends more extensive use of prophylaxis |
Figure 1.2  These pulmonary emboli removed at autopsy look like casts of the deep veins of the leg where they originated.

Figure 1.3  At least 90 percent of pulmonary emboli are thought to originate in major leg veins. This patient underwent a thrombectomy. The thrombus has been laid over the approximate location in the leg veins where it developed.

Correcting the situation
Despite extensive data documenting the incidence, the risk factors and the measures for preventing venous thromboembolic diseases, the magnitude and seriousness of these problems are not always appreciated. Although physicians in some hospitals are both aware of which patients are at risk of venous thrombosis and adopt a policy of prophylaxis in many of them, physicians in other hospitals do not systematically tackle the problem because of lack of understanding and awareness.

Consequently, patients continue to die and to suffer needlessly. Though doctors may be alert to the signs of venous thromboembolism, they may miss the presence of this condition because more than 80 percent of all deep vein thrombi have no clinical signs; PE too, is often silent. Even objective methods of diagnostic screening may fail to detect the presence of life-threatening thrombi. Clearly, if thrombi can be prevented from occurring in the first place, many of these problems could be overcome.
“Our review of more than 70 randomized trials in 16,000 patients demonstrated that the perioperative use of sc heparin can prevent about half of all pulmonary emboli and about two-thirds of all DVT”

Patients at risk
Patients at risk of venous thromboembolism can be identified, and there are methods of prophylaxis available to reduce the incidence of complications in many of these patients.

Prophylaxis is preferred to treatment, as venous thromboembolism can be hard to diagnose and, in the case of PE, there is often no warning that the patient is at risk. Death due to PE is often immediate or occurs within 1 to 2 hours of onset. In high-risk groups of patients, it is more cost effective to protect against DVT and PE than to treat these conditions when they occur.

“Pulmonary embolism originates in the deep veins of the legs in 90 percent or more of cases”

Among the patients at greatest risk of venous thromboembolism are those who have experienced trauma. This can be accidental trauma or the trauma of surgery. Other factors, such as immobility, contribute to increasing risks.

Surgery
In surgery, the risks of venous thromboembolism have been defined and quantified, and the ability to lessen the problem by use of prophylactic measures has been shown in a number of studies. While an individual surgeon may claim to never have known a case of postoperative PE, the statistics prove that this is a problem that is far greater than is generally realized. Often, cases of late fatal PE escape detection, as sudden death at home could be attributed to some other cause. After a patient is discharged from the hospital, a postoperative DVT may go unnoticed by the surgeon, as it is quite likely the patient will be diagnosed and treated by a primary care physician. Even patients who die in the hospital shortly after surgery may not be considered as victims of PE if there has not been a thorough autopsy to establish the cause of death conclusively.

Before any operation, a surgeon is required to weigh the benefits of surgery against the potential risks to the patient. By understanding which types of patients are at risk of venous thromboembolism and why, the surgeon will be able to make the best and most rational use of the currently available forms of prophylaxis, thereby ensuring that the surgery leads to a true improvement in quality of life for the patient.
### Table 1.3  Percentage risks of venous thrombosis

<table>
<thead>
<tr>
<th></th>
<th>Deep vein thrombosis</th>
<th>Pulmonary embolism</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trauma (fracture)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip</td>
<td>40-60</td>
<td>4-7 (fatal)</td>
</tr>
<tr>
<td>Tibia</td>
<td>40-50</td>
<td></td>
</tr>
<tr>
<td>Multiple injury</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td><strong>Elective surgery</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General abdominal</td>
<td></td>
<td>0.2-1.5 (fatal)</td>
</tr>
<tr>
<td>Calf</td>
<td>3-51</td>
<td></td>
</tr>
<tr>
<td>Proximal</td>
<td>2-10</td>
<td></td>
</tr>
<tr>
<td>General surgery for cancer</td>
<td>40-70</td>
<td></td>
</tr>
<tr>
<td>Splenectomy</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Thoracic</td>
<td>20-45</td>
<td></td>
</tr>
<tr>
<td>Gynecological</td>
<td>7-45</td>
<td></td>
</tr>
<tr>
<td>Prostatectomy</td>
<td>7-51</td>
<td></td>
</tr>
<tr>
<td>Peripheral vascular</td>
<td>4-43</td>
<td></td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>29-43</td>
<td></td>
</tr>
<tr>
<td>Orthopaedic</td>
<td></td>
<td>1-5 (fatal)</td>
</tr>
<tr>
<td>Calf</td>
<td>17-84</td>
<td></td>
</tr>
<tr>
<td>Proximal</td>
<td>40-80</td>
<td></td>
</tr>
<tr>
<td>Knee</td>
<td>10-20</td>
<td></td>
</tr>
<tr>
<td>Knee replacement</td>
<td>17-57</td>
<td></td>
</tr>
<tr>
<td>Calf</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Proximal</td>
<td>50-70</td>
<td></td>
</tr>
<tr>
<td>Hip replacement</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Calf</td>
<td>45-60</td>
<td></td>
</tr>
<tr>
<td>Proximal</td>
<td>40-50</td>
<td></td>
</tr>
<tr>
<td>Pregnancy</td>
<td>1-3</td>
<td></td>
</tr>
<tr>
<td>Postpartum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical Patients</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>10-38</td>
<td></td>
</tr>
<tr>
<td>Heart failure</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Stroke</td>
<td>33-60</td>
<td></td>
</tr>
<tr>
<td>Paraplegia</td>
<td>59-100</td>
<td></td>
</tr>
</tbody>
</table>
There has been a wealth of published material supporting the view that venous thromboembolism is a serious but often preventable complication for many patients, and one of the most authoritative publications was that of the NIH, which, in 1986, produced a consensus document recommending wider use of prophylaxis.
Section 2
What are we trying to prevent?

The source of most important thromboemboli is deep venous thrombosis in the proximal veins of the legs. It is therefore important to understand the pathogenesis of these thrombi, their formation and eventual embolization.

Postoperative thrombosis is very common but most thrombi lyse spontaneously, particularly those formed in the calf veins. Signs and symptoms will only appear if venous outflow becomes obstructed because of a thrombosis or when a thrombus embolizes into the pulmonary circulation.

Although many thrombi are initially asymptomatic, they are often clinically significant because they can be complicated by pulmonary embolism and the post-phlebitic syndrome.

Pulmonary emboli
When PE strikes unexpectedly, it may be the result of the passage of an asymptomatic thrombus into the pulmonary circulation. When a large thrombus blocks major pulmonary vessels, cardiogenic shock will occur, followed quickly by circulatory failure and death. Morbidity can also result from smaller thromboemboli reaching the lungs. Small thrombi can lead to blockage of areas of lung vasculature and to symptomatic pulmonary embolism, often characterized by shortness of breath. This condition poses dangers to the patient, as a subsequent embolism, small or large, could be fatal.

Deep vein thrombosis
Thrombi in the veins of the legs may also be symptomatic or asymptomatic. Most thrombi originate in distal veins, and some extend to the proximal veins. Generally, proximal vein thrombosis is more serious than distal vein thrombosis, but both are important because of their potential to grow and to embolize. Asymptomatic PE has been observed by routine lung scanning in about 50 percent of patients with documented proximal vein thrombosis and, conversely, asymptomatic venous thrombosis is found at venography in 70 percent of patients presenting with PE, thus emphasizing the close links between these conditions.

The clinical signs and symptoms of DVT are nonspecific and, although most DVTs will be asymptomatic, many will be clinically significant.

The diagnosis of both PE and DVT will be outlined more fully in Section 3.

Table 1.5  The consequences of venous thrombosis

<table>
<thead>
<tr>
<th></th>
<th>Distal DVT</th>
<th>Proximal DVT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Symptomatic PE</td>
<td>Asymptomatic PE</td>
</tr>
<tr>
<td></td>
<td>Fatal PE</td>
<td>Post-phlebitic syndrome</td>
</tr>
</tbody>
</table>

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Other clinical conditions linked with thromboembolism
The post-phlebitic syndrome is thought to be the long-term result of DVT in some patients. Whether the DVT is symptomatic or asymptomatic, specialists now believe that this syndrome, which is characterized by varicose veins, edema, skin pigmentation, induration and ulceration, is often the result of venous valvular damage sustained during an episode of thrombosis.

Pathogenesis of venous thromboemboli
Venous thrombi are different from arterial thrombi, not only in terms of their site of formation but also in their appearance and make-up. Compared with the pale-colored, platelet-rich arterial thrombi, venous thrombi are red, less compact and contain many red blood cells entrapped in a fibrin network. These thrombi can arise in the large venous sinuses of the calf or in the region of valve cusps. Factors which are thought to influence thrombus formation are

- alterations in blood flow (stasis will encourage clot formation),
- changes in the vessel wall (trauma or injury to the vessel wall may trigger coagulation), and
- alterations in the blood (changes in constituents such that coagulation exceeds natural anticoagulant and fibrinolytic systems, or otherwise blood viscosity increases).

Once formed, the fate of a thrombus depends on the persistence of factors involved in its formation. Many will spontaneously lyse or will be reduced in size, but others may extend and embolize, posing a threat to the patient.

Venous stasis
Normally, venous return from the legs is enhanced by contraction of the calf muscles, which help to propel blood towards the heart. But stasis can occur in states of immobility when the blood is allowed to pool in the intramuscular sinuses of the calf, which become dilated during prolonged rest.

Autopsy studies have revealed that the prevalence of DVT is high in patients confined to bed for a week or more prior to death. Patients are exposed to these same risks when confined to bed either before or after surgery.

<table>
<thead>
<tr>
<th>Table 1.6 Virchow’s Triad</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Component change in vessel wall</strong></td>
</tr>
<tr>
<td>Femoral vein damage in total hip replacement</td>
</tr>
<tr>
<td><strong>Blood flow stasis</strong></td>
</tr>
<tr>
<td>More time for clotting</td>
</tr>
<tr>
<td>Small thrombi not washed away</td>
</tr>
<tr>
<td>Viscosity increased</td>
</tr>
<tr>
<td><strong>Coagulability</strong></td>
</tr>
<tr>
<td>Increase in tissue factor</td>
</tr>
<tr>
<td>Presence of activating factors</td>
</tr>
<tr>
<td>Decrease in coagulation inhibitors</td>
</tr>
</tbody>
</table>

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Elderly, bedridden patients, those with varicose veins and pregnant women have a tendency to suffer from venous dilatation in the legs, and this can lead to venous pooling or stasis and, so, to an increased risk of venous thromboembolism.

Venous obstruction is another cause of stasis. Patients who have pelvic tumors or proximal vein thrombosis are prone to stasis and, so, to thrombus formation, as are patients with heart failure.

Increases in blood viscosity in conditions like primary proliferative polycythaemia, erythrocytosis, dysproteinaemia and in some malignant disorders can also lead to stasis.

**Vessel wall damage**

Damage to vessels contributes to venous thrombosis in patients undergoing both traumatic and elective hip surgery when the femoral vein is likely to be put under strain. Knee surgery, varicose vein stripping, severe burns and lower limb trauma are also associated with vessel damage.

When the endothelium of a vessel is damaged, exposing the subendothelium to blood, platelet adhesion and aggregation are triggered, and tissue-factor is activated, which promotes blood coagulation.

**Blood coagulability**

Changes in the blood itself can affect coagulability and so promote thrombus formation. With increasing age, we all have increased activation of blood coagulation, but some patients have genetic deficiencies of anti-thrombin III, protein C or protein S that make them particularly susceptible to venous thromboembolism at a young age. Malignancy is also associated with changes in blood coagulability, and patients who have cancers are therefore at high risk of DVT and PE.

Exposure of Factor XII in the blood to collagen, when vessels become damaged, leads to activation of the intrinsic pathway of coagulation, and platelets may also play a role under conditions of tissue damage. Leukocytes migrating into areas of tissue damage and the exposure of blood to tissue thromboplastin are also thought to activate the extrinsic pathway of coagulation through Factor X activation and the intrinsic pathway through Factor IX activation.

The body has certain protective mechanisms to help guard against hypercoagulability. Three plasma proteins have been identified as important modulators of coagulation: antithrombin III, protein C and protein S. The fibrinolytic system, by producing tissue-plasminogen-activator, urokinase and plasminogen-activator-inhibitor, is also important in the physiological control and lysis of thrombi.

In short, any changes that give rise to an increase in active clotting factors, or that decrease the level of inhibitors or the activity of the fibrinolytic system, will disrupt the normal equilibrium. The result will be an increased tendency to form venous thrombi. Clinical risk factors which predispose to venous thromboembolism by activating blood coagulation include extensive surgery, trauma, burns, infusion of Factor II, VI, IX and X, disseminated malignant disease and myocardial infarction.

There may be some merit in performing extensive hematological tests in younger patients who have DVT of uncertain origin.
**The implications of not preventing thrombosis**

Untreated or inadequately treated venous thrombosis is associated with a high rate of complications. While anticoagulant therapy can be used to treat diagnosed cases of thrombosis, the fact remains that a high percentage of clinically significant thrombi are silent and escape diagnosis. Protecting patients suspected of being in at-risk situations against the occurrence of venous thromboembolism by use of prophylactic measures is preferable to waiting for cases of DVT and PE to occur. Agents and measures exist to provide adequate prophylaxis for a large number of patients.

About 20 percent of untreated, silent calf-vein thrombi and from 20 to 30 percent of untreated, symptomatic, calf-vein thrombi extend into the popliteal vein, and this is associated with a 40 to 50 percent risk of clinically detectable PE. Studies have also found that inadequately treated proximal DVTs have a 47 percent recurrence rate over the next 3 months.

<table>
<thead>
<tr>
<th>Stimulation</th>
<th>Inhibition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activation of coagulation</td>
<td>Circulating inhibitors (antithrombin III, protein C, protein S)</td>
</tr>
<tr>
<td>Vessel wall damage</td>
<td>Endothelial cell components (heparin sulphate, thrombomodulin)</td>
</tr>
<tr>
<td>Stasis</td>
<td>Fibrinolytic system (tPA, PAI-1 plasminogen)</td>
</tr>
</tbody>
</table>

These figures compare poorly with the percentage risk reduction values that are possible when prophylaxis is employed. In recent years, awareness of the long-term problems associated with an episode of DVT has increased. The prevalence of the post-phlebitic syndrome has been estimated to be as high as 2 percent in the general population and occurs in 50 to 70 percent of subjects who sustain proximal vein thrombosis. The syndrome is thought to be caused by venous hypertension resulting from venous valve destruction or persistent obstruction due to thrombosis. The high pressure renders the perforating veins of the calf incompetent, and flow of blood is then directed into the superficial system, leading to edema and impaired viability of subcutaneous tissues or, when severe, to ulceration.

In patients who have thrombi extending into the ileo-femoral veins, swelling persists. Other symptoms or signs of the post-phlebitic syndrome such as calf pain, pigmentation and induration around the lower third of the leg, and ulceration, may not manifest until as late as 5 to 10 years after the initial thrombotic event.
Patients at risk of thrombosis
Clearly, venous thromboembolism in its many guises represents a far greater clinical problem than is widely realized. However, many patients can be identified as being at risk, and prophylactic measures and treatments exist that could be employed to reduce the likelihood of thrombosis in these patients.

In Section 1, Table 1.1, an extensive list of patients at risk of DVT and PE is provided. One particular patient population at risk of thromboembolism, and for whom prophylaxis is very well suited, is surgical patients.

Surgery is a well-recognized risk situation, particularly for patients with additional risk or predisposing factors. In a review of more than 70 randomized trials, involving more than 16,000 patients, it has been shown that the perioperative use of low-dose heparin prophylaxis can prevent

- about half of all PE and
- about two-thirds of all DVT.

This strongly supports the notion that prophylaxis can reduce both morbidity and mortality in surgical patients.

Not all surgery carries the same risks for patients but, by careful categorization of patients into low, moderate, high and very high-risk groups, a surgeon can ensure that those patients in most need of prophylaxis are selected and protected.

Any patient at moderate, high or very high risk is a candidate for thromboembolic prophylaxis because of the high likelihood that he or she will suffer the consequences of a subsequent thrombosis.

Why are surgical patients at risk?
Most patients requiring surgery are unwell to a greater or lesser extent and may have been immobile or inactive because of this. After most types of surgery, patients will also experience a period of enforced bed rest and immobility. In orthopaedic surgery, traction and plaster casts further reduce postoperative movement, and all these factors lead to venous stasis and an increased likelihood of thrombosis. Direct vascular damage can be important. For example, in hip replacement therapy, there may be kinking or twisting of major veins, predisposing the patient to postoperative DVT. Pelvic surgery also carries a high risk because of the pressure on large veins during the dissection.

All operations involve a degree of tissue damage; activated coagulation factor levels in blood following surgery using general anesthesia will be high. The more extensive the damage, the more likely activation of coagulation.

The longer an operation, the greater the risks, and patients undergoing surgery lasting more than 30 to 45 minutes are considered at risk. Recent studies have also suggested that the type of anesthesia employed can influence the degree of thrombosis risk. Spinal and epidural anesthetics seem to be less thrombogenic than general anesthesia.
Patients can be classified according to risk

Low-risk patients
General medical patients and surgical patients younger than 40 years who undergo minor operations (general anesthesia lasting fewer than 30 minutes) appear to be at a low risk for DVT. Early ambulation should provide adequate protection in this group of low-risk patients.

Moderate-risk patients
Surgical patients older than 40 years who undergo major operations requiring anesthesia lasting longer than 30 minutes, but who have no additional DVT risk factors, appear to be at moderate risk of developing postoperative DVT. Adequate protection for these patients can be provided using either graduated compression stockings, low-dose unfractionated heparin b.i.d. or intermittent pneumatic compression.

High-risk patients
Following abdominal surgery, the incidence of DVT is from 16 to 30 percent. Gynecological surgery, particularly in older women, is also associated with significant risk (7 to 45 percent DVT), and the major trauma involved in a Caesarean section carries similar risks. Urological operations, especially transvesical prostatectomy (40 percent risk of DVT), are often performed on older patients and also constitute high risk.

<table>
<thead>
<tr>
<th>Type of surgery</th>
<th>Risk reduction (±SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>67% (±4)</td>
</tr>
<tr>
<td>Orthopaedic</td>
<td>*68% (±7)</td>
</tr>
<tr>
<td>Urological</td>
<td>75% (±15)</td>
</tr>
<tr>
<td>Any surgery</td>
<td>68% (±3)</td>
</tr>
</tbody>
</table>

*This may be an overestimate, as the end-point used in most studies was fibrinogen leg scan.

Cardiac and thoracic surgery are considered to be of moderate risk although, as described above, the patient may have additional risk factors such as malignancy which bring this surgery into a higher risk category. Another high-risk group are patients undergoing neurosurgery, where the risks of DVT range from 9 to 50 percent. However, in this group, anticoagulant therapy is seldom used for fear that intracerebral or spinal cord hemorrhage might occur.

Any patient undergoing surgery who has any of the medical conditions or other risk factors, listed in Table 1.1 of Section 1, is at risk of thromboembolism and should be assessed for possible prophylaxis.
Adequate protection for high-risk patients can be provided using either low-dose unfractionated heparin, low-molecular-weight heparin or intermittent pneumatic compression. Addition of graduated compression stockings to these measures may provide additional protection.

**Very-high-risk surgery**

One example of the highest risk surgery is orthopaedic surgery. Common high-risk orthopaedic procedures are hip or knee replacement and hip fracture repair. Hip replacement, both elective and following fracture, may provide patients with a new lease on life but also carries an unacceptably high risk of DVT and of fatal PE, which has led most orthopaedic surgeons to insist that their patients receive the most effective perioperative prophylaxis available.

Many patients undergoing hip or knee surgery are old, and this alone increases the risks of thrombosis. Other risk factors of this form of surgery are major dissection and trauma at operation, torsion of the femoral vein and immobility of the patient both before and after the operation.

Data summarized from the NIH consensus panel show the overall incidence of DVT after elective hip surgery to be from 45 to 70 percent, of clinical PE to be about 20 percent and of fatal PE to be from 1 to 4 percent. The incidence levels are even higher following emergency surgery for fracture.

Other types of very-high-risk surgery are operations to remove malignant tumors in the thoracic region. Patients undergoing thoracic surgery because of malignancy are already in poor health, the surgery may be long and involve extensive dissection and pressure on large veins, and there is an increase in activation of coagulation, all of which put the patient at risk of venous thromboembolism.

In general, adequate protection for very-high-risk patients can be provided using either low-molecular-weight heparin or warfarin. Addition of intermittent pneumatic compression and graduated compression stockings to these agents may provide additional protection. Specific recommendations are provided in Chapter-2.
Section 3
Approaches to prevention

The results of surveys of surgeons have revealed that, in many hospitals, prophylaxis for deep vein thrombosis and pulmonary embolism is not yet standard practice, despite overwhelming evidence of the benefits to patients when properly used. The reasons for this lack of awareness are many and various. Some surgeons claim that venous thromboembolism is not a problem they encounter, others do not wish to provide prophylaxis to all patients to protect a few, some surgeons fear that methods of prophylaxis carry their own inherent risks for the patient and, at an institutional level, hospitals may lack an organized strategy for thromboprophylaxis or doubt its cost effectiveness. The whole issue of costs will be considered separately in Section 5.

Three approaches are available to address the problem of postoperative venous thromboembolism. These are

- treatment of established DVT/PE
- screening for subclinical disease
- primary prevention

Treating established thrombosis

Clearly, one option is for the surgeon to wait until venous thromboembolism occurs and then to treat aggressively. The treatment of choice is anticoagulant therapy, usually involving continuous IV or sc heparin and oral anticoagulants. Treatment with heparin is usually continued for 5 to 10 days. During this time, daily monitoring of the activated partial-thromboplastin-time is recommended. A course of oral anticoagulants is then prescribed, which the patient may continue to take for months. However, drugs such as warfarin need careful monitoring, and attention should be paid to possible drug interactions during therapy.

A number of randomized controlled trials have demonstrated the safety and efficacy of treating DVT with subcutaneous injections of low-molecular-weight heparin. This new treatment modality provides an opportunity to treat most patients at home. Initial treatment of DVT with low-molecular-weight heparin has become a standard of care in many European countries. This approach seems destined to become the standard in the United States after the FDA approves this indication (probably in 1998).

It is important to ensure that anticoagulants are administered in adequate doses and for adequate periods of time. Patients with proximal vein thrombosis who are treated inadequately have a 40 to 50 percent recurrence of DVT in the following 3 months, and patients with recurrent DVT given anticoagulants for only 3 months are likely to have a 20 percent recurrence of their problem over the next year. A 5-day course of heparin in patients who have calf-vein thrombosis that is not followed by oral anticoagulant therapy will have a 20 percent failure rate in the following 3 months.

In cases of established venous thrombosis or PE in which anticoagulant therapy is contraindicated or has failed, patients may be treated with an inferior vena cava filter, which is inserted either through the jugular or femoral vein by a fairly simple surgical procedure. The idea is that such devices can be used to trap a thrombus which has broken off, thus intercepting it before it embolizes into the lungs.
In cases of massive embolism, thrombolytic therapy with agents such as streptokinase, urokinase or tissue-plasminogen-activator (tPA) may be used to dissolve the PE and so relieve the obstruction. Treatment with thrombolytic agents is expensive and associated with an increased risk of hemorrhage, including hemorrhagic stroke. Therefore, such treatment should be limited to patients who have major PE or underlying cardio-respiratory disease and in whom early lysis is judged to be life-saving.

Limitations of treatment
The most serious problem with the “wait and see” approach to venous thromboembolism is that many patients will suffer serious venous thrombosis or PE as their first manifestation. In the extreme, such a “wait and see” approach could have fatal consequences. Most patients who die from PE do so within 30 minutes of onset, leaving little time for diagnosis or effective intervention.

“... further reductions in mortality from pulmonary embolism must come through systematic prophylaxis in high-risk patients rather than a policy of ‘wait and treat’”

In addition, there is growing awareness that silent DVT can lead, often years later, to the post-phlebitic syndrome, which diminishes quality of life for many otherwise healthy patients. Only by preventing the initial problem - venous thromboembolism - can this major burden on healthcare be avoided.

Screening for DVT
Systematic screening for subclinical venous thromboembolism followed by early treatment to prevent embolism is not feasible in all patients who have recently undergone surgery. In addition, screening programs in high-risk patients may not be possible or affordable in most centers, and, indeed, even in specialized centers, screening is limited to a clinical trial setting.

While screening may not be a suitable approach to DVT and PE prevention for these reasons, it is nevertheless worth reviewing the available methods of diagnosis and screening for thrombosis as they are used in clinical trials of prophylaxis and therapy to establish the efficacy of different regimens.

Diagnosis and screening of venous thromboembolism
The application of diagnostic tests for venous thrombosis and PE differs depending on whether they are used as screening tests in postoperative patients or medical patients at risk, or whether they are used to confirm a diagnosis in patients who have clinical features consistent with venous thrombosis or PE. Only the use of tests for screening is relevant to this discussion. The diagnostic tests used to screen for venous thrombosis are clinical diagnosis, fibrinogen-uptake test (leg scan), impedance plethysmography (IPG), doppler ultrasonography, duplex ultrasound scanning and venography. In the late 1980’s, duplex ultrasound scanning became the principal diagnostic screening test for DVT in North American hospitals. The other tests are now primarily of interest as historic or research methods.
### Table 1.9  Hospitalized patients screened for DVT with routine leg scanning or venograph (from original reports)

<table>
<thead>
<tr>
<th>Patient Category</th>
<th>Screening test(s)</th>
<th>%DVT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Medical</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>LS/P</td>
<td>25</td>
</tr>
<tr>
<td>Transvenous pacing</td>
<td>LS/V</td>
<td>33-53</td>
</tr>
<tr>
<td>Hemiplegia (stroke)</td>
<td>LS/V</td>
<td>59-89</td>
</tr>
<tr>
<td>Paraplegia</td>
<td>LS</td>
<td>13-29</td>
</tr>
<tr>
<td>Intensive care</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trauma</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip fracture</td>
<td>V</td>
<td>40-49</td>
</tr>
<tr>
<td>Tibial fracture</td>
<td>V</td>
<td>45</td>
</tr>
<tr>
<td>Multiple injuries</td>
<td>V</td>
<td>35</td>
</tr>
<tr>
<td><strong>Elective surgery</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General abdominal</td>
<td>LS/V</td>
<td>3-51</td>
</tr>
<tr>
<td>Splenectomy</td>
<td>LS</td>
<td>6</td>
</tr>
<tr>
<td>Thoracic</td>
<td>LS</td>
<td>20-45</td>
</tr>
<tr>
<td>Gynecologic</td>
<td>LS</td>
<td>7-45</td>
</tr>
<tr>
<td>Prostatectomy (open)</td>
<td>LS</td>
<td>29-51</td>
</tr>
<tr>
<td>Prostatectomy (closed)</td>
<td>LS</td>
<td>7-10</td>
</tr>
<tr>
<td>Aorto-femoral</td>
<td>LS/V</td>
<td>4-43</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>LS</td>
<td>29-43</td>
</tr>
<tr>
<td>Meniscectomy</td>
<td>V</td>
<td>8</td>
</tr>
<tr>
<td>Knee surgery</td>
<td>V</td>
<td>17-57</td>
</tr>
<tr>
<td>Knee replacement</td>
<td>V</td>
<td>84</td>
</tr>
<tr>
<td>Hip replacement</td>
<td>V</td>
<td>30-65</td>
</tr>
<tr>
<td><strong>Pregnancy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postpartum</td>
<td>LS</td>
<td>1-3</td>
</tr>
</tbody>
</table>

LS = Leg Scan;  P = Plethysmography;  V = Venogram.

**Clinical diagnosis**
Clinical diagnosis alone is inaccurate as a screening test because it fails to detect large, clinically important thrombi.

**Venography**
Venography, or phlebography as it is sometimes called, is the gold standard for the diagnosis of venous thrombosis as it is the only test which is able to detect thrombi in both the calf and the thigh. This test is termed *invasive* as it involves injecting radiopaque contrast medium into a vein in the dorsum of the foot. The contrast medium then fills the veins, making it possible to visualize the thrombus as a filling defect. The drawback of venography as a screening test is that it is *painful* and, therefore, cannot be repeated readily. Venography is used for the diagnosis of venous thrombosis in asymptomatic patients and to evaluate the effectiveness of prophylaxis measured in a *clinical trial setting*. 
Impedance plethysmography (IPG)
IPG is a noninvasive test that operates on the principle that changes in blood volume in the leg can be measured as changes in the electrical resistance of tissue as it is monitored on a chart recorder. In this test, patients are asked to lie flat with their feet slightly raised while a cuff is inflated around the leg to a pressure above that normally found in veins. The result is that blood cannot flow back to the heart, and the calf veins fill with blood. Electrodes on the lower leg measure the maximum venous capacity while the cuff is inflated, and the maximum venous outflow can be measured on release of the cuff pressure. These two measurements are reduced from normal levels in patients with an obstructing thrombus. IPG is much less useful as a screening test in asymptomatic patients than it is in diagnosing venous thrombosis in symptomatic patients. This is because the IPG is only sensitive to proximal vein thrombi that produce a critical obstruction. These proximal vein thrombi occur much more frequently in patients who have symptoms of venous thrombosis than in asymptomatic patients. Consequently, the IPG only picks up a minority of asymptomatic proximal vein thrombi and fails to detect most calf-vein thrombi when used as a screening test in high-risk patients.

Doppler ultrasonography
Doppler ultrasonography is another noninvasive method of diagnosing DVT. A beam of ultrasound waves is directed at a vein and is reflected at a frequency that varies according to the rate of movement of red blood cells through that vein. This return signal is detected as an audible tone. As normal blood flow varies with respiration, a low pitch sound can be recorded that disappears as the vein is compressed. As the compression is released, there is an augmented sound if the vein under examination is patent.

This technique, like IPG, is relatively sensitive to obstructing proximal vein thrombi but insensitive to calf-vein thrombi. Therefore, it has limitations when used as a screening test for detecting DVT.

Duplex scanning (B-mode imaging)
This diagnostic test uses the principles of ultrasound to image the deep veins of the leg. The technique is able to identify the proximal veins, including the femoral and popliteal veins, but is limited in its ability to identify calf veins and cannot identify pelvic veins. Therefore, as a screening test, duplex scanning has limitations similar to those of IPG and doppler ultrasonography, although recent studies have indicated that it is more sensitive to proximal vein thrombi (including asymptomatic nonocclusive) than IPG. Approximately 60 percent of proximal vein thrombi are detected by this method when it is used to screen patients undergoing hip surgery.

Pulmonary embolism
Patients who show clinical signs of PE usually require urgent investigation and rapid treatment if the diagnosis of PE is confirmed. Symptoms of PE may include dyspnea, chest pain or hemoptysis. As with DVT, clinical examination alone and simple investigations such as chest X ray and ECG are unreliable methods of diagnosis. Patients who may have PE are usually investigated by perfusion lung scanning, since a normal perfusion lung scan excludes the diagnosis. If the perfusion lung scan shows a large defect, then a ventilation lung scan is performed since a normal ventilation scan in the presence of a large perfusion defect is strongly suggestive of the diagnosis of PE. In cases where the perfusion scan is abnormal but only shows a small defect, or if there is a defect seen by
both perfusion and ventilation scanning, a pulmonary angiogram is usually required to either confirm or rule out a diagnosis of PE.

**Active prevention**

Treatment of established DVT and PE, and screening followed by treatment, are not without their problems. Many surgeons throughout the world today feel that these reactive approaches to postoperative thrombosis are unacceptable given the mounting evidence that prophylaxis around the time of surgery can greatly reduce the chances of thrombosis.

Simple predictions and calculations point to the benefits of general prophylaxis over no prophylaxis and over screening followed by treatment.

“Primary prophylaxis is likely to be more effective, less expensive, and is the prophylaxis of choice in most clinical circumstances. Secondary prevention by screening should never replace primary prophylaxis, and is reserved for those patients in whom effective primary prophylaxis is either contraindicated or unavailable”

Hull RD, Raskob GE and Hirsh J (1986) Chest 89, 3745-3835

Many of the prophylactic measures that can be taken are simple, and newer approaches to prophylaxis are proving that the risks of postoperative thrombosis can be reduced considerably with little risk to the patient.

Not all surgery carries the same risks and not all patients have clear risk factors but, for those patients known to fall into the categories of moderate to very high risk (see Sections 1 and 2), there are strong arguments in favor of employing one or a combination of the prophylactic measures that will be outlined in detail in Section 4.
Section 4
The available prophylactic measures

Prevention better than treatment
Having identified which patients are at risk of venous thromboembolism, the next choice for the physician is to select the most appropriate prophylactic measure for the patient’s circumstances. The ideal primary prophylactic should be effective, free from clinically important side effects, and well accepted by patients, nurses and medical staff. It should be easy to administer, relatively inexpensive and require minimal monitoring.

Over the years, the available methods of thromboprophylaxis have been refined and improved to give maximum risk reduction for patients liable to suffer postoperative, post-traumatic or medical thrombosis. In principle, all prophylaxis is directed either at suppressing activation of blood coagulation or at increasing venous blood flow in the leg veins. There are two general types of prophylaxis - mechanical methods and pharmacological agents.

Mechanical methods
Early mobilization of patients as soon as possible after surgery is thought to reduce the chances of venous thrombosis, and physiotherapy can be categorized as an important mechanical method. The other mechanical methods of prophylaxis act on the same principle as early mobilization, in that they stimulate calf muscles and put pressure on the calf and leg veins, thus discouraging stasis and venous pooling of blood in the lower extremities.

These methods are virtually free of side effects. Graded compression stockings have been shown to be effective in reducing postoperative venous thrombosis in general surgical patients and in neurosurgical patients. The stockings are inexpensive and should be considered in all at-risk surgical patients. However, those that have been most carefully evaluated come in numerous sizes and should be fitted individually to ensure that pressure is correctly graded (highest at the ankle and decreasing in a proximal direction). Intermittent pneumatic leg compression enhances blood flow in the deep veins of the legs. This method is virtually free of side effects and is particularly useful in patients at high risk of bleeding, such as those undergoing neurosurgery, major knee surgery and prostatic surgery. Studies have also shown that compression is as effective as low-dose heparin in patients undergoing abdominal surgery.

Analysis of studies on the use of mechanical methods has shown that general surgery patients on average have about a 9 percent chance of developing deep vein thrombosis (most of which are calf) if stockings or compression are used compared with a 20 to 24 percent chance if no prophylaxis is employed.

Pharmacological agents
Agents include unfractionated heparin (low-dose and adjusted-dose), low-molecular-weight heparins (LMWH’s) and heparinoids, warfarin, and dextran. These agents prevent, to differing degrees, thrombus formation after surgery by interfering with blood coagulation (heparin, warfarin) or blood flow and fibrin stability (dextran).
“... the application of prophylactic measures is much more effective for preventing death and morbidity from pulmonary embolism than is treatment of the established event”

Hull RD, Rascob GE and Hirsh J (1986) Chest 89, 3745-3835
Bleeding is the most common side effect associated with antithrombotic drugs and is the cause of many surgeons rejecting the notion of prophylaxis, particularly prior to surgery. Bleeding can be classified as major and minor. Major bleeding is any overt bleeding associated with a marked fall in hemoglobin, any intracranial or retroperitoneal bleeding, or any situation requiring transfusion or re-operation, whereas minor bleeding could be considered as hematoma at wound sites or other forms of bleeding not associated with a significant fall in hemoglobin.

Clinical trials and large scale studies have measured the effectiveness of each of these types of drugs, sometimes compared with placebo and sometimes compared with each other. In most cases, the trials have not been of sufficient size to provide reliable estimates of the rate of pulmonary embolism, with and without prophylaxis, though the data do support the effectiveness of these agents in preventing DVT.

**Unfractionated heparin**

Low doses of heparin prevent thrombosis by inhibiting thrombin and Factor Xa. Heparin is a mucopolysaccharide extracted from animal tissues, which is composed of different molecular weight fractions varying in size from 3000 to 30,000 daltons.

Heparin can be administered by subcutaneous injection. *When used as prophylaxis, low-dose heparin is usually given at a dose of 5000 U every 8 or 12 hours postoperatively.* The first dose may be given 2 hours preoperatively although some surgeons who fear bleeding during surgery may wait until immediately after surgery before giving heparin. Heparin is then usually continued for about 7 days in general surgical patients or until such time as the patient becomes fully ambulatory. Low-dose heparin does not require laboratory monitoring and is simple to use and fairly convenient to administer. *It is one of the agents of choice for moderate to high-risk general surgical and medical patients,* as it can reduce the risk of venous thromboembolism by 50 to 70 percent.

An overview of more than 70 studies looking at the prophylactic effects of heparin in general and orthopaedic surgery found that DVT, as detected by fibrinogen-uptake scans, could be reduced from approximately

- 22 to 9 percent in general surgery, i.e., a 59 percent risk reduction
- 48 to 24 percent in orthopaedic surgery, i.e., a 50 percent risk reduction
- 41 to 14 percent in urological surgery, i.e., a 68 percent risk reduction.

This same review noted that heparin reduced the frequency of both fatal and nonfatal PE, and in some of the larger trials, (for example, the International Multicentre Trial) this reduction was found to be significant. *Mortality was also less in the patients given heparin prophylaxis.*

Although low-dose heparin is considered generally to be safe and free from serious bleeding side effects, this agent has some potential to cause minor bleeding, and, so, it should not be used in patients undergoing neurosurgery or eye surgery. It is contraindicated in patients with known heparin sensitivity, patients with a defect in hemostasis, patients with severe hypertension, and when there has been a hemorrhagic accident.
Low-dose heparin is considered to be as effective as dextran in elective hip surgery, where it can reduce the incidence of venous thrombosis by 50 percent. It is, however, less effective than adjusted-dose heparin, oral anticoagulants or LMWH.

**Adjusted-dose heparin** has been found to be more effective than low-dose heparin in elective hip surgery and in patients who have a spinal cord injury. The adjusted-dose heparin regimen is an 8-hourly regimen of sc heparin that is begun 2 days before surgery. The starting dose of heparin is 3500 U with subsequent dose-adjusted steps of 500 to 1000 U to achieve an activated partial-thromboplastin-time (APTT) in the upper normal range 6 hours after injection. This regimen is obviously more complicated and requires more monitoring than low-dose heparin but is more effective in very-high-risk patients.

In this study, the dose of heparin in the adjusted-dose group was increased gradually to an average of 18,900 U/day by the 7th day after surgery (range 13,500-30,000 U for 24 hours). Compared with fixed low-dose heparin prophylaxis using 3500 U sc 8 hourly, the adjusted-dose regimen reduced the overall thrombosis rate in patients having elective hip surgery (measured in the operated leg by venography on days 7 through 9 after surgery) from 39 to 13 percent (P<0.01) without increasing blood loss.

**Table 1.12 Heparin has a long history of use in the prevention of thrombosis**

<table>
<thead>
<tr>
<th>History of heparin and prophylaxis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maclean and Howell 1916-1922</td>
</tr>
<tr>
<td>Low-dose heparin (De Takats, 1950)</td>
</tr>
</tbody>
</table>

**Oral anticoagulants (vitamin K antagonists)**

Oral anticoagulants, such as warfarin, administered in doses that prolong the prothrombin time (to an international normalized ratio (INR) of between 2.0 to 3.0) are found to be effective in preventing postoperative thrombosis in all risk categories. The prophylaxis can be started preoperatively, at the time of surgery or immediately after surgery, but there is a 3- to 4-day lag before these drugs have their maximum anticoagulant effect.

Oral anticoagulants can be used in two ways:

- Commence with a low dose (3 mg) 10 to 14 days before surgery with the aim of adjusting the INR to 1.3 to 1.5 at the time of surgery and then gradually increase the dose to obtain an INR of 2.0 to 2.5 at 3 to 4 days postoperatively. This approach is relatively safe but impractical because it requires many days of careful monitoring.

- Commence with a dose of 5 mg on the evening of the operation or the first postoperative day, aiming for an INR from 2.0 to 3.0 on the 4th or 5th postoperative day. This approach is more practical and has been shown to be effective and relatively safe but still requires careful laboratory monitoring.
The drawbacks to oral anticoagulants are that they require monitoring of prothrombin times and carry a high potential for bleeding complications unless very carefully monitored.

Dextran
Dextran, a glucose polymer available as two fractions of differing molecular weights, dextran-40 and dextran-70, is believed to exert its antithrombotic effects through a number of mechanisms. Dextran is also a plasma volume expanding agent and as such reduces blood viscosity, increases blood flow and reduces venous stasis. It is infused from the time of surgery over a period of 4 to 6 hours and is then given daily for 2 to 5 days postoperatively. The chosen doses of dextran vary greatly. One commonly used regimen is 500 ml dextran-40 daily over the first 3 to 5 days after surgery, followed by additional doses every third day thereafter while the patient remains bedridden. Although dextran is the favored prophylactic agent in some hospitals, studies have shown that it is less effective than warfarin or LMWH in preventing DVT. It has also been associated with allergic reactions or bleeding in some patients, problems that can now be prevented by hapten inhibition, and carries the potential for volume overload. For these reasons dextran has not been widely adopted, at least in North America, as a means of DVT prevention.

Table 1.14 Advantages and disadvantages of dextran use

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective in high risk surgery</td>
<td>• IV administration inconvenient in postoperative period</td>
</tr>
<tr>
<td></td>
<td>• Relatively high bleeding risk</td>
</tr>
<tr>
<td></td>
<td>• Possibility of volume overload</td>
</tr>
<tr>
<td></td>
<td>• Risk of allergy or anaphylaxis</td>
</tr>
</tbody>
</table>

Low-molecular-weight heparins and heparinoids
Low-molecular-weight heparins (LMWHs) have been introduced as promising prophylactic agents. Interest in LMWHs as potential antithrombotic agents was stimulated by two observations in the mid-1970s and early 1980s. The first was the finding that LMWH fractions prepared from standard unfractionated heparin (UFH) progressively lose their ability to prolong the APTT while retaining their ability to inhibit Factor Xa. The second was the observation that LMWHs produce less bleeding in experimental models for an equivalent antithrombotic effect than the UFH from which they are derived. The LMWHs in clinical use are pro-
uced from UFH by depolymerization and are approximately one-third the molecular size of UFH.

They have a number of advantages over standard heparin preparations and, in clinical trials and major studies throughout the world, have been found to be a highly effective and safe form of prophylaxis in patients undergoing orthopaedic and general surgery, and in stroke patients. They are considered the most effective form of prophylaxis in hip surgery, knee surgery and following major trauma. Studies in both general and orthopaedic surgery have suggested that LMWHs are more effective prophylaxis than standard low-dose heparin. The LMWHs also appear to be superior to dextran. There is evidence that differences between the effects of UFH and LMWH on platelet aggregation or vessel wall permeability may be responsible for the differences in the hemorrhagic properties of these glycosaminoglycans.

A number of different LMWHs have been approved for use in Europe and three are now approved for use in North America: enoxaparin (Lovenox®), dalteparin (Fragmin®) and ardeparin (Normiflo®). The LMWHs have a longer half-life than standard heparin and are highly effective and safe when used for prophylaxis in surgical patients.

At least eight randomized studies compared LMWH with standard heparin in patients undergoing abdominal surgery. A number of the early trials evaluating prophylactic LMWH reported excessive bleeding, which, in the light of subsequent experience, was probably due to use of excessively high doses of LMWH. In two large studies, the incidence of thrombosis was significantly lower in the LMWH group, but there was no difference detected in the rate of bleeding between the LMWH and UFH groups. In a recent study in general surgical patients, comparing LMWH with no treatment, patients randomized into the LMWH group had significantly lower total mortality and thromboembolic mortality.

LMWH has also proved to be very effective in reducing postoperative venous thrombosis in patients who have undergone elective hip surgery. In most studies using LMWH, the agent was given preoperatively and then once daily postoperatively; however, a double blind placebo-controlled trial in which a LMWH was given twice daily starting 12 to 24 hours after hip replacement found that venous thrombosis could be markedly reduced - from 42 percent in the control group to 12 percent in the LMWH group. Proximal vein thrombosis was reduced from 23 percent in the control group to 4 percent in the LMWH group in this same trial, without excessive bleeding. Other studies, using the preoperative regimen and then once-daily LMWH, have reported similarly low rates of venous thrombosis after hip surgery, and a recent study found that LMWH was significantly more effective than adjusted-dose heparin in reducing the incidence of proximal vein thrombosis.

In another recent study comparing a LMWH with dextran in hip surgery, a relative risk reduction of 70 percent was seen for the LMWH group. Patients received either 40 mg/day enoxaparin 12 hours before surgery and for 8 days thereafter, or 500 ml infusions of dextran during surgery, on the day of surgery and on days 1 and 3 after surgery. The rate of DVT was 22 percent in the dextran group but was considerably lower in patients who received enoxaparin - just 6 percent.

Three recently published randomized studies in patients undergoing total knee replacement have shown similar favorable results using LMWH, which is now considered the prophylaxis of choice following knee replacement surgery.
Fewer studies have been performed in medical patients at risk of thrombosis. However, the results for LMWHs look promising. Two studies in stroke patients suggest from 60 to 80 percent relative reduction in thrombosis risk can be achieved by administering LMWHs prophylactically, and a third study in elderly bedridden patients points to a similar risk reduction for DVT following administration of LMWH.

A number of different LMWHs have been developed. All are produced from UFH by depolymerization techniques that differ from manufacturer to manufacturer. Although often described collectively, each LMWH has different properties. While, as a group, these agents can be said to exhibit certain prophylactic properties that compare well with other methods of prophylaxis, the clinical trial results obtained with one LMWH should not be extrapolated to predict the effect of another LMWH. They differ in dosage and in their effects on blood parameters. The dosing schedule and administration of enoxaparin illustrate the advantages of this class of prophylactic drug.

Enoxaparin has a half-life of approximately 4.4 hours and is 90 percent bioavailable. Unlike standard heparin, which has to be administered two or three times a day, a once or twice daily sc injection of enoxaparin affords the patient adequate protection against the risks of thrombosis. It is therefore convenient to use and is well accepted by physicians, nurses and patients.

Two different dosing regimens are available for use in either very-high-risk patients or high-risk patients. In a very-high-risk situation, such as orthopaedic surgery, enoxaparin is given at a dose of 30 mg twice a day, with the first dose administered 12 hours after surgery, and doses repeated twice daily thereafter until the risk of thrombosis is considered to have passed. There is currently much interest in continuing to administer LMWHs for a longer period after surgery to protect against the longer-term threat of thrombosis.

In high-risk general surgical patients enoxaparin is given in a dose of 40 mg once a day, with the first dose given 2 hours before surgery and then repeated once daily until the risk of thrombosis is thought to have diminished.

It is assumed that many of the contraindications to the use of heparins will apply to the use of LMWHs, but there is evidence that the risks of heparin-induced thrombocytopenia are lower with LMWHs.

**Combined prophylactic modalities**

There is a lack of good data comparing combinations of prophylactics with agents or methods used alone. However, almost all surgical patients are thought to benefit from the use of stockings or compression in addition to a pharmacological agent.

**Using the current methods of prophylaxis**

There is still some debate as to exactly when and for how long prophylaxis for venous thrombosis should be given. Even established agents, such as low-dose and adjusted-dose heparin, are used earlier and longer by some doctors than by others. Should pharmacological prophylaxis begin pre- or postoperatively? How long should a course of prophylaxis last? Are there differences in the type, dose and duration of prophylaxis to be used in different risk groups?
Choice of prophylaxis in different patient groups

Most often, the decision to use prophylaxis is based on the presence of one or more of the risk factors known to predispose patients to postoperative or medical thrombosis. There have been attempts to refine this process by adding laboratory tests to the clinical risk factors and deriving formulae in which risks are weighed to yield a predictive index for a given patient. Most of these indices have not proved helpful, and, consequently, the best approach is still for doctors to rely on their knowledge of risk factors and to weigh the benefits of prophylaxis for each patient.

All patients suspected of being at risk of venous thrombosis should be encouraged to keep mobile.

Indeed, in all general surgery and medical patients, early ambulation and graduated compression stockings should be considered automatically. Patients in high-risk groups should receive, in addition, pharmacological prophylaxis.

The choice of prophylaxis has widened since 1986 when the consensus statements on methods of prophylaxis in at-risk patients were first issued. Since the advent of LMWHs, many experts now believe that the efficacy and ease of use of these compounds make them the prophylaxis of choice in most very-high-risk patients.

Patients at high risk should receive either low-dose heparin or intermittent pneumatic compression, while patients at very-high-risk should receive LMWH or oral anticoagulants.

Orthopaedic surgery, for example hip surgery, carries a very high risk of thrombosis and all patients should receive prophylaxis with either LMWH, adjusted-dose heparin, or oral anticoagulants. Results from studies in orthopaedic surgery suggest that LMWHs have a profile that makes them the prophylaxis of choice. Major knee surgery is another area where LMWHs have become the favored method of prophylaxis. Genitourinary surgery and neurosurgery are procedures

<table>
<thead>
<tr>
<th>Agent</th>
<th>No. of patients</th>
<th>Thrombosis(%)</th>
<th>Risk % reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspirin</td>
<td>309</td>
<td>40</td>
<td>13</td>
</tr>
<tr>
<td>Dextran</td>
<td>123</td>
<td>17</td>
<td>57</td>
</tr>
<tr>
<td>Warfarin</td>
<td>208</td>
<td>25</td>
<td>48</td>
</tr>
<tr>
<td>Low-dose heparin</td>
<td>301</td>
<td>22 (pooled analysis)</td>
<td>57</td>
</tr>
<tr>
<td>Control</td>
<td>979</td>
<td>47</td>
<td>-</td>
</tr>
<tr>
<td>LMWH (enoxaparin)</td>
<td>50</td>
<td>12 (single studies)</td>
<td>72</td>
</tr>
</tbody>
</table>

**Table 1.15** Summary of efficacy of various prophylactic approaches in elective hip surgery with venography as the endpoint (Salzman and Hirsh, 1987)
following which intermittent pneumatic compression may be the safest, most effective form of prophylaxis.

**Medical patients**, such as those who have suffered **myocardial infarction** or **hemiplegia**, may also benefit from thrombosis prophylaxis. Information is sparse about the success of preventive measures. Heparin prophylaxis may have some role in post-myocardial infarction patients, and may also prevent DVT in patients who have recently suffered a **stroke**.

The greater safety margin of LMWHs has sparked interest in their possible use in ischemic stroke for the prevention of thrombosis. Bedridden patients suffering from complaints such as pneumonia or heart failure are known to be at increased risk of venous thromboembolism, and both low-dose heparin and LMWH appear to achieve substantial risk reductions in these patients.

**Prophylaxis: pre- or postoperative?**

Many North American surgeons do not wish to begin prophylaxis, even with LMWHs, preoperatively and prefer instead to begin with the first dose of heparin or LMWH 12 hours after surgery, especially when spinal anesthesia was used.

**For how long should prophylaxis continue?**

Studies using both standard heparin and LMWH often state that prophylaxis was continued for about 7 days after surgery, or until such time as the patient became mobile. However, **no one actually knows how long the danger of venous thromboembolism persists after surgery**, and there is much debate currently over when to stop prophylaxis.

A recent study of patients after their discharge from the hospital following major surgery confirmed that the risks of developing thromboembolic disease can extend beyond the patient's stay in the hospital. Once patients return home, they may be even less mobile than they were in the hospital. Of 57 patients studied, 13 developed DVT during the 6 weeks after surgery, despite having shown no signs of this complaint while in the hospital.

Many patients receive heparin or LMWH for about one week after surgery and are then switched to oral anticoagulants for several weeks to provide some continuing protection. However, the apparent high safety margin and excellent efficacy of LMWHs has led doctors in some hospitals to suggest that daily injections continue for longer periods including periods after the patient has returned home. Because of the ease of injection, surgical patients in Europe are now often asked to continue their LMWH prophylaxis at home by self-administration. In North America and Europe there is growing enthusiasm for treating acute DVT at home with LMWHs. This has led to the wide adoption of home treatment protocols by managed care organizations and hospitals. While this development should make it easier to implement continued DVT prophylaxis with LMWHs at home, at least in 1997, **the price of LMWHs in North America was considerably higher than the price of oral anticoagulants.** Thus, the most cost-effective approach to long-term DVT prophylaxis appears to be LMWHs for one to two weeks followed by oral anticoagulants if longer protection seems warranted.
Section 5
The cost effectiveness of prophylaxis

There is now a fairly extensive body of literature on the relative efficacy and safety of the various available forms of prophylaxis. In contrast, there are very few definitive reports on the economic implications of prophylaxis. The reluctance of many hospitals to adopt an organized strategy for the prevention of venous thromboembolism is sometimes blamed on the fact that this information is not forthcoming. However, there have been reviews of cost effectiveness that clearly identify those patients who will benefit clinically and financially from prophylaxis, as distinct from those in whom prophylaxis would have no overall benefits.

“... the decision to use prophylaxis should be based not on economic grounds but on avoiding the tragic and unnecessary loss of life due to massive pulmonary embolism”

In any calculation of cost effectiveness, it is difficult to quantify the cost of time lost through illness or indeed the cost of death. Similarly, the morbid long-term effects of venous thromboembolism cannot easily be measured in monetary terms. But, it is possible to compare the costs of a course of prophylaxis with the costs of diagnosis, treatment and hospital care involved in dealing with a thrombosis once it has occurred. A study performed in Sweden compared the cost effectiveness of three alternatives in patients 40 years and older who underwent general surgery, surgery for cholelithiasis or elective hip surgery:

• no prophylaxis
• general prophylaxis with low-dose heparin
• selective therapy following screening with fibrinogen-uptake alone or with venography.

Three different categories of surgery were chosen to represent the different degrees of risk to patients in different groups.

“in elective hip and general surgery, at least, treatment costs can be minimized with the general prophylaxis alternatives”

When calculating the costs of treatment, general hospital costs, such as those for room and board were kept separate from those for medication, diagnosis, monitoring, treatment of complications and prolonged hospitalization due to re-admission or complications. There was also no concession made for the costs of lost productive capacity during illness.

From this study, it emerged that general prophylaxis was the best option in terms of reducing the frequency of venous thrombosis - a reduction of 70 percent. General prophylaxis was also the best approach to reducing patient mortality after surgery.
When costs were analyzed, it became clear that, both in elective hip surgery and general surgery, the most cost-effective alternative is general prophylaxis, while in surgery for cholelithiasis, the general prophylaxis option was not quite as cost effective as no prophylaxis, given the rate of complications.

The prophylaxis chosen, that is, low-dose heparin, was associated with an increased frequency of hemorrhagic complications, as compared with the alternative of not using prophylaxis.

<table>
<thead>
<tr>
<th>Study population</th>
<th>General surgery</th>
<th>Surgery for cholelithiasis</th>
<th>Elective hip surgery</th>
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</thead>
<tbody>
<tr>
<td>No prophylaxis</td>
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<td>662</td>
<td>2944</td>
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<tr>
<td>General prophylaxis</td>
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<td>1073</td>
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<td>Selective treatment following fibrinogen test</td>
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<td>3984</td>
<td>1932</td>
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</table>

“General prophylaxis will also minimize hospital costs per patient”

Both deep vein thrombosis and pulmonary embolism were significantly reduced by general prophylaxis in this study. Selective treatment after screening was shown to be the least effective option in terms of both clinical outcome and cost.

Thus, in very-high-risk (orthopaedic) and high-risk (general) surgery, prophylaxis is both clinically and financially worthwhile. The case for prophylaxis in low-risk (cholelithiasis) surgery cannot be made on financial grounds, even though there will be a reduction in the patient’s risk of postoperative thrombosis.

“Our results do suggest that the failure to use any method of prophylaxis may be difficult to justify on grounds of concern over either the outcome or cost of care”
Another study confirming the cost effectiveness of prophylaxis in orthopaedic surgery was performed in the USA. Several different types of prophylaxis including warfarin, low-dose heparin, graduated compression stockings, intermittent pneumatic compression and heparin plus stockings were compared with no prophylaxis. As well as reducing the number of fatalities by about 50 percent, prophylaxis was also found to be cost effective.

When the costs of diagnostic tests to confirm DVT and PE in patients who had not received prophylaxis were calculated and added to the costs of treatment and hospital time spent managing established thrombosis, it was clear that, in this very-high-risk group of patients, prophylaxis was justified not only on the grounds that it reduces morbidity and mortality but also because it was more cost effective. Prophylaxis could reduce average costs of care by $19 to $182 per patient.

This chapter was adapted from an educational monograph originally developed by the Thrombosis Forum, Jack Hirsh MD, editor, which was published in Europe in 1991 by Colwood House Medical Publishers and sponsored by an unrestricted grant from Rhône-Poulenc Rorer, Inc. Permission was granted to adapt this material.
INTRODUCTION
Deep venous thrombosis (DVT) and pulmonary embolus (PE) are major risk factors for patients undergoing surgical or other invasive procedures, and thromboprophylaxis should be considered for all these patients. Prevention of venous thromboembolism (VTE), a combination of DVT and PE, is more effective than treatment and is an important aspect of patient care before, during, and after surgery. Identification of risk factors should be used as a basis to determine if pharmacological and/or mechanical thromboprophylaxis should be initiated.

Deep vein thromboembolisms and PE may be asymptomatic and difficult to detect. Patients with DVT may exhibit symptoms such as local tenderness or impaired drainage of blood vessels distal to the obstruction. In addition to producing localized symptoms, DVT can break off and travel to the lungs, resulting in PE. The incidence of PE is greater when the DVT is close to the heart. Studies indicate as many as 80% of orthopedic surgical patients may develop DVT. Without preventive treatment 4% to 10% of these patients will develop PE. Deep venous thrombosis and subsequent PE remain the most common cause for emergency readmission and death following joint replacement surgery, even when preventive therapies are used.

The National Quality Forum, the Joint Commission on Accreditation of Healthcare Organizations, the Centers for Medicare and Medicaid Services, the American College of Obstetricians and Gynecologists, and many other organizations have created protocols or recommendations on the prevention of venous stasis/DVT/PE. The American College of Chest Physicians recommends that every hospital develop a formal strategy or protocol addressing the prevention of thromboembolic complications. The Surgical Care Improvement Project developed two process measures recommending the presence of orders for venous thromboembolism prophylaxis for surgical patients and that patients receive prophylaxis for DVT within 24 hours before or after surgery. Use of protocols for prevention of DVT might save the lives of two-thirds of the patients who die from PE. The protocols known to be effective for the management of PE have been severely underused. Estimates indicate that 1% of patients admitted to hospitals die because of PE and at least one-half of these at-risk patients might be saved with effective prophylaxis use. Perioperative nurses should be knowledgeable about venous stasis and should participate in multidisciplinary teams to develop policies, procedures, and protocols to reduce the risk of venous stasis and assist in preventing DVT and PE.

The purpose of this guideline is to provide a framework that perioperative registered nurses and others can use to develop and implement policies, procedures, and protocols for prevention of venous stasis and DVT/PE. This document does not cover the long-term effects of venous stasis, such as venous stasis ulcers or their postoperative treatment.

The “AORN guideline for prevention of venous stasis” is based on current available research and expert opinion. It is assumed that ongoing research will result in new knowledge, procedures, and medical and nursing interventions for prevention of DVT. This guideline may not apply to every individual and may require modification based on the specific needs of a given patient. Review of this document has been solicited from content experts considered knowledgeable in the prevention of venous stasis and included representatives from academia, medicine, perioperative nursing, and clinical nurse specialists.

DEFINITIONS
For purposes of this document the following definitions apply.

Anticotting factors: Naturally occurring proteins that, when activated, prevent blood clot formation.

Anticoagulant: Substance that prevents or delays blood from clotting.
Antiembolism stockings: Elastic stockings that reach from the foot to just below the knee or to the thigh. The stockings are tighter at the ankles than at the knee. The varying tightness of compression stockings helps circulate blood that collects in the calves.10

Central access venous catheters: A catheter designed for continuous access to the venous system. Frequently implanted into the internal jugular, antecubital, or subclavian vein.

Clotting factors: Naturally occurring proteins which, when activated, cause blood clot formation.11

Deep vein thrombosis: Development of a thrombus (ie, clot) in one of the deep veins of the body, frequently the iliac or femoral veins or major upper-extremity veins. These clots can break off from the vein, travel through the heart, and lodge in the arteries of the lungs, causing a potentially fatal PE.10

Intermittent pneumatic compression device (IPC): A mechanical device that uses intermittent pneumatic compression, applied via a cuff that inflates and deflates sequentially or uniformly. The cuff may be applied to the foot, calf, or thigh.1

Post-thrombotic syndrome or postphlebitic syndrome: A chronic inflammation of a vein that destroys the valves after an episode of thrombophlebitis or the presence of a thrombus.12,13

Pulmonary embolism: A thrombus that breaks free from a vein, travels through the veins, reaches the lungs, and lodges in a pulmonary vessel. A pulmonary embolism is a potentially fatal condition that may cause death within minutes to hours.10

Thrombolytic medication: A medication used for dissolving existing blood clots.

Thrombophlebitis: The formation of a venous clot accompanied by inflammation of the vein. This may be the result of trauma to the vessel wall; hypercoagulability of the blood; infection; chemical irritation; intra- or postoperative venous stasis; prolonged sitting, standing, or immobilization; or a long period of IV catheterization.10

Venous stasis: A condition that occurs when the normal blood flow though a vein is slowed or halted.10

Venous thromboembolism: A condition including DVT and PE.14

Venous thrombosis (phlebothrombosis): A condition that occurs when a clot forms within a vein without inflammation.10

Virchow’s triad: A descriptor listing the three main causative factors in DVT formation—endothelial damage, hypercoagulability, and venous stasis.15

Prevalence

The prevalence of thromboembolic events varies by the type of event. The following classifications describe the most common types of thromboembolic phenomenon.

Venous Thromboembolism

This combination of DVT and PE affects more than 1 in 1,000 adults annually in the United States, causing discomfort, suffering, and occasionally death.16 More than 2.5 million people annually are diagnosed with DVT.17 Deep vein thrombosis factors into approximately 600,000 hospital admissions annually, and 50,000 to 200,000 of these patients will suffer from PE. In the United States, PE is the third most common cause of death. Pulmonary embolism occurs most frequently in patients admitted to the hospital for a diagnosis other than PE or DVT.1,18 A DVT formed in the leg is not life-threatening, but if the clot breaks loose and moves to the lungs, a life-threatening PE can result.17 Pulmonary embolism is a medical emergency affecting both the cardiovascular and respiratory systems and has mortality rates that may be as high as 25%.17

Pulmonary embolism is reported to be the number-one preventable hospital-acquired complication. Autopsies reveal an estimated 10% to 25% of all deaths in hospitals involve a PE.3 Some studies have shown that in 60% of inpatient deaths the patient had a PE, and as many as 70% of these were not diagnosed.18

One study has shown that 8.83 surgical patients with risk factors per 1,000 develop DVT. The study included all surgical patient discharges defined by specific diagnosis-related groups and coded for an operating room procedure according to the International

Guideline
Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) classification system. Patients who were excluded
• had ICD-9-CM codes for DVT or PE at time of admission,
• were obstetrical patients in Major Diagnostic Category 14,
• were patients where a procedure for interruption of the vena cava was the only operating room procedure, or
• the procedure performed occurred before or on the same day as the first operating room procedure.

In this study, the day of the operative procedure was not available on some data files, creating a limitation in the study. This may have led to an incidence rate slightly lower than if that information had been available.19

Without prophylaxis, the incidence of objectively confirmed, hospital-acquired DVT is approximately 10% to 40% among medical or general surgical patients and 40% to 60% following major orthopedic surgery.2 In one study, 42% of hospitalized patients with a diagnosis of DVT and PE did not receive prophylaxis.20,21

Approximately 300,000 patients are newly diagnosed with DVT yearly in the United States, and possibly three to four times this many may occur without obvious symptoms and thus are not detected.16 About 80% of DVT are thought to be silent, with no signs or symptoms. There is a direct correlation between asymptomatic DVT and future development of a symptomatic VTE. One study of critical care patients found that patients with asymptomatic DVT had a significantly greater rate of PE development during their index hospitalization compared to those patients with symptomatic DVT (ie, 11.5% vs 0% respectively; \( P = .01 \)).9

In the United States, published studies estimate that 200,000 to 600,000 patients receive a diagnosis of DVT and PE annually. These two diagnoses are thought to contribute to 60,000 to 200,000 deaths. If simple preventive measures were instituted, many of these deaths could be prevented. Patients need to be warned about DVT risks and assessed for risk factors, and measures need to be used.22

Many hospital-acquired VTE are not evident until after discharge, due to the increased number of same-day surgery procedures and the decreased patient length of stay.9 Lack of VTE prevention often leads to readmission, a rise in anticoagulation therapy complications, an increased risk of long-term morbidity from post-thrombotic syndrome, and a higher rate of future recurrent thrombosis.9 An estimated $2.9 billion are spent annually in the United States for the treatment of DVT and PE.9 The most serious outcome resulting from hospital-acquired VTE is death from an undiagnosed PE.

Superficial Venous Thrombophlebitis (SVT)
Generally, thrombophlebitis is used to describe superficial thrombophlebitis that occurs in the veins located near the surface of the body, but the term often is used synonymously with DVT.23 Superficial thrombophlebitis occurs annually in 400 patients out of 100,000.24 Cases of SVT occur more frequently in women. The average age of occurrence for women is 58 years. In men, SVT occurs in 35% to 46% of surgical patients. The average age of occurrence for men is 54 years.24,25 Ninety percent of thrombophlebitis occurs in the leg, with 10% occurring in the arms and other parts of the body. As many as 60% to 80% of the cases of SVT arise in patients with varicose veins. These patients frequently experience the thrombophlebitis after minor trauma such as a bruise to the varicosity.24,25

Post-Thrombotic or Postphlebitic Syndrome (PTS)
This is a chronic inflammation of a vein that occurs after an episode of thrombophlebitis or the presence of a thrombus and that destroys the valves. Long-term venous thrombosis is associated with PTS syndrome. The prevalence of PTS has been estimated to be as high as 2% in the general population and occurs in 50% to 67% of subjects who sustain proximal vein thrombosis.12,17,26

Pathophysiology
To understand how DVT and PE phenomena can be prevented, practitioners need an understanding of the pathophysiology of the venous system and clotting mechanisms.
**GROSS ANATOMY OF THE VENOUS SYSTEM**

The venous system has superficial and deep veins whose function is to return blood to the heart and lungs. Superficial veins are located just under the skin. These superficial veins connect to the deep veins located in the large muscles by the collecting (ie, communicating) veins. Deep veins located in the muscles are largely responsible for returning blood flow to the heart. The venous system is a low-pressure system that acts against gravity; therefore, it acts in a reverse pressure gradient. Valves within the veins prevent backflow in a healthy venous system. The pressure of blood flow against a normal functioning valve is what opens the valve.

Most collecting veins are suprafascial and can dilate to accept large quantities of blood at any one time without interfering with the normal function of the venous system. From the collecting veins, venous blood travels to the deep veins largely located in the lower extremities. The movement of blood from the feet to the right atrium depends on a complex system of muscle pumps. These pumps propel the blood against gravity and are located in the arch of the foot, calf, and thigh. The contraction of the muscle pumps increases the velocity of the blood and forces the blood upward, which in turn increases the pressure against the valve cusps within the vein, causing them to open and push the blood forward. Healthy, functioning muscle pumps and venous one-way valves move the deoxygenated blood toward the right atrium and prevent pooling or backflow in the vascular system.

Deep vein thrombosis develops frequently in the proximal deep veins, with 90% of DVTs occurring in the deep veins of the leg, usually in the femoral vein. In the upper extremities, the increasing use of indwelling venous access catheters is associated with a greater number of DVT cases. Mortality rates for DVT occurring in the legs range from 13% to 21%, and up to 48% in the arms. If the thrombus partially or completely blocks the flow of blood through the vein, blood begins to pool and build up below the site, potentially resulting in chronic swelling and pain. The valves in the blood vessels also may be damaged, leading to venous hypertension.

**CLOTTING CASCADE**

The clotting cascade is an intricate system of proteins and enzyme actions that must occur in sequence to produce clots, inhibit further clot formation, or cause destruction of an existing clot. Initiation of one of two systems in the clotting cascade (ie, the intrinsic or extrinsic system) begins the actual clot formation process. The following is a simplified explanation of the complex blood clotting progression.

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**Intrinsic clotting path**

Internal vascular irritation or lesions initiate the intrinsic system with the mobilization of pro-proteins and pro-enzymes to stimulate the transport of kallikrein, Factors XII, XIIa, XI, Xla, IX, and Xa to the site of the irritation.

**Extrinsic clotting path**

If a laceration occurs to the blood vessel the extrinsic system is activated, releasing tissue factor proteins from the damaged cells as well as mobilizing Factors VII and VIIa. The intrinsic system also is stimulated into action if the damage extends to the internal surface of the vein. The two systems unite at IX and IXa and continue the clotting process.

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Soft clot formation

The next step is soft clot formation, which occurs when Factor X and calcium phospholipids unite with prothrombin, yielding thrombin formation. Thrombin is anchored to the phospholipids, limiting thrombin to the site of the injury or irritation. In the presence of Vitamin K, thrombin and Factor V unite, initiating the development of fibrinogen, which yields fibrin to form a mesh-like structure called a soft clot. **Requires the Presence of Vitamin K.**

- Factor X + calcium phospholipid + Factors XII and X
- Prothrombin
- Thrombin + Factor V

Fibrinogen → Fibrin → SOFT CLOT

Hard clot formation

After soft clot formation, thrombin activates Factor XIII, a fibrin-stabilizing factor. This factor along with the fibrin-soft-clot-matrix, traps platelets, aggregating the platelets at the injury site and resulting in a hard clot.

- Thrombin + platelets
- Activates Factor XIII and fibrin-stabilizing factor
- HARD CLOT

Clotting termination

At some point, the clotting cascade must terminate, and eventually the clot dissolves. The termination process begins with release of Factors V, VII, VIII, XIII, and Protein C and Protein S. The actual release of Protein C signals the clotting cascade to dismantle. Protein C targets Factors V and VII to slow and eventually stop clot formation.

- Factors V, VII, VIII, and XIII
- Protein S and Protein C

Factors V, VII, VIII, and XIII + Protein S and Protein C = Signal to stop clot formation

Inhibition of clotting process

Antithrombin III is produced to inhibit thrombin. Tissue damage or irritation also stimulates mast cell production. Mast cell production releases heparin and other proteases that function as mild antithrombin-type substances and other antithrombin III enhancers. These actions stop clot formation.

- Antithrombin III + Heparin + Other inhibitor

Antithrombin III + Heparin + Other inhibitor = Termination of clotting process

Clot dissolution (Fibrinolysis)

Fibrinolysis, or clot dissolution, requires plasminogen and tissue plasminogen activator to release plasmin. Plasmin, along with heparin, has a binding affinity to the fibrin, digesting the clot.

- Plasminogen + Tissue Plasminogen Activator + Heparin

Plasminogen + Tissue Plasminogen Activator + Heparin = Clot dissolution
PATHOGENESIS OF DEEP VEIN THROMBOSIS AND PULMONARY EMBOLISM

Factors that influence venous thrombus formation can be explained by a theory developed by Rudolf Karl Virchow in 1856. This theory, known as Virchow’s triad, describes three conditions that contribute to the formation of DVT. Deep vein thrombosis is caused by an abnormality in one or all three of the components of Virchow’s triad.

VIRCHOW’S TRIAD

Virchow’s triad describes the three main causative factors in DVT formation: endothelial damage, hypercoagulability, and venous stasis. The following conditions all can contribute to these causative factors and result in DVT.

VESSEL WALL INJURY. Any vessel wall injury that does not include the interior vessel wall initiates the extrinsic pathway of the clotting cascade. When the endothelium (eg, interior) of a vessel is damaged, causing roughening of the vessel wall, the intrinsic pathway of the clotting cascade is initiated, resulting in platelet adhesion and aggregation that promotes blood coagulation at the site of the injury.

Trauma and surgical procedures or interventions cause instantaneous injury to vessel walls, both interior and exterior, and create a risk for thrombosis. Venipunctures, intravenous therapies, venous access catheters, and heart valves cause a constant irritant and also add to the potential for DVT occurrence.

BLOOD FLOW ALTERATION. Alterations in blood flow (ie, venous stasis) allow blood to pool within the veins, causing clot production. These clots increase in viscosity and do not get washed away rapidly related to the stasis. They may sit and enlarge and then may be propelled into the remainder of the venous system. Blood flow alteration may be caused by venous stasis, which can occur in sedentary or bedridden patients or pregnant women, especially those with varicosities. Patients with blood dyscrasias that contribute to blood pooling, such as proliferative polycythemia, erythrocytosis, or some malignancies, also can lead to stasis problems.

Blood flow also can be altered due to venous obstruction. A population at risk due to pooling of venous blood includes patients with pelvic tumors, those having long abdominal or pelvic laparoscopic surgical procedures, and patients with congestive heart failure.

Smoking, another cause of blood flow alteration, is a chemical irritant that causes vasoconstriction and thus reduces the oxygen carried in the blood. This alters the blood flow and leads to retention of blood in the vascular system.

ALTERATIONS IN COAGULATION. Any increase in the coagulation profile (ie, hypercoagulability) of the blood can result in DVT formation. Factors increasing the risk of blood clot formation can be due to any of the following:

- an increase in the number or amount of clotting factors released (eg, surgery, burns, trauma);
- a decrease or lack of factors that stop the clotting cascade;
- a decrease in the fibrinolysis action of the clotting system caused by medications (eg, estrogen), inflammatory diseases (eg, inflammatory bowel disease), or chronic systemic diseases (eg, lupus erythematosus);
- absence of coagulation modulators that signal clot formation to stop (eg, protein C, protein S, and antithrombin III, and changes in the activity of the fibrolytic system or presence of tissue plasminogen activator, plasmin, or heparin); and
- age. As people age, the presence of additional venous thrombus risk factors within Virchow’s triad (below) escalate the possibility and occurrence of DVT formation.
**SUPERFICIAL VENOUS THROMBOPHLEBITIS**

Superficial thrombophlebitis occurs when one of the elements of Virchow’s triad—ie, vessel wall injury, blood flow, and coagulation—stimulates the clotting process. Superficial thrombophlebitis causes an acute inflammatory reaction that triggers the thrombus to adhere to the vein wall.25

**POST-THROMBOTIC OR POSTPHLEBITIC SYNDROME**

This syndrome is thought to be caused by venous hypertension resulting from venous valve destruction or persistent obstruction due to thrombosis. The high pressure present renders the perforating veins of the calf incompetent. Blood flow is then directed into the superficial system, leading to edema and, when severe, impaired viability of subcutaneous tissues, leading to venous stasis ulceration.13,17,26

**ASSESSING FOR RISK FACTORS**

It is imperative for perioperative practitioners to identify the risks factors for DVT and/or PE in their nursing assessments.15,28,29 Assessment of risk factors begins with the initial patient assessment. It continues throughout the patient’s surgical/interventional procedure and postoperative recovery until he or she is discharged from care. The process of assessing patients for DVT or PE begins with the identification of risk factors. Risk factors are grouped into three general categories.

**Age.** Risks for DVT increase in frequency as a person advances in age, beginning at age 40.1

**Primary admitting medical diagnosis.** The primary admitting medical diagnosis (ie, admitting diagnosis, primary diagnosis) is the patient’s diagnosis when presenting to the health care facility. The perioperative nurse should develop a plan of care based on increased risk for DVT when this diagnosis includes any of the following:

- trauma;9
- orthopedic fractures (eg, hip, major bone, pelvis, knee);14,22
- burns;15,30
- planned surgery or interventional procedures where
- patient positioning includes flexion and rotation of a joint that may cause constriction of a vessel leading to vascular damage or28,31
- surgery may cause an interruption of circulation (eg, tourniquet usage);28
- use of central venous indwelling catheters;9,32 and
- procedures lasting longer than 30 to 45 minutes.15

**Past medical history.** The patient’s past medical history may include or be independent from the current admitting diagnosis. The medical history assessment is based on the patient’s past, current, and familial medical history. It should include an assessment of

- any recent surgery (especially orthopedic, abdominal, or thoracic);7
- history or family history of thrombosis, coagulopathy, blood clots, blood-clotting disorders, DVT, or PE;9
- history of cancer (ie, malignancy with or without treatment);9
- varicosities or leg swelling;9
- obesity;9
- smoking;9
- chronic obstructive pulmonary disease;9
- estrogen or hormone therapy;9
- nephrotic syndrome;9
- pregnancy or postpartum period of less than one month;9
- recent myocardial infarction;9
- congestive heart failure;9
- history of atrial fibrillation;9
- inflammatory bowel disease;9
- sedentary/nonambulatory lifestyle greater than 72 hours;10
- immobility, including that related to casts, braces, or splints;9
- stroke;9
- infection or sepsis;9
- dehydration or hypovolemia;15
- recent travel (eg, prolonged air travel or riding in a vehicle);29 and
- ethnicity (ie, greater risk in Caucasians and African Americans).15

The presence of any of these in the patient’s history indicates a need for increased surveillance for DVT.
SPECIAL CONSIDERATIONS FOR HIGH-RISK PATIENTS

PEDIATRIC PATIENTS

Today more children survive diseases previously considered incurable. Along with this increased survival, the number of children experiencing DVT is increasing (eg, approaching 0.2% in North America). A second factor for increasing the rate of childhood DVT is the increasing use of central venous access catheters.9

The epidemiology of DVT in children differs from adults related to the location of the thrombi. Venous thromboembolism in children usually is located in the upper body venous system, primarily because this is the preferred location for central venous access catheter placement.9 One study found that approximately 40% of thrombi in children occur in the upper venous system, but in adults this occurs only approximately 1% of the time.9 The greatest risk factor for DVT in children is the placement of central venous access catheters or arterial catheters.9

GENERAL SURGERY

The risk of thromboembolic complications in the general surgery population may be elevated due to more extensive surgical procedures being carried out on older and more critically ill patients, the use of preoperative chemotherapy, and the shorter duration of prophylaxis related to decreased lengths of stay in the hospital. The risk for DVT is decreased by earlier mobilization and increased use of thromboprophylaxis.9

GYNECOLOGIC SURGERY

The rates of VTE after gynecologic surgery are similar to the rates of general surgery patients. Gynecologic patients frequently have a combination of risk factors that make them more susceptible to VTE. Laparoscopic gynecological procedures appear to have a lower risk of VTE compared to open procedures but can result in impaired venous return from the legs and activation of the factors involved in coagulation.9

LAPAROSCOPIC SURGERY

The potential for a longer surgical time for laparoscopic operations leads to a greater risk of VTE. Venous stasis is created in these patients related to both pneumoperitoneum and the use of the reverse Trendelenburg position. The length of stay associated with laparoscopic procedures leads to a decrease in the length of the thromboprophylaxis time, and mobility after discharge is difficult to control.9

UROLOGIC SURGERY

The rates of VTE in urological patients are decreasing, but VTE remains an important nonsurgical complication. The increased risk factors for patients undergoing major urologic surgery are very similar to those undergoing gynecologic procedures, including the use of the lithotomy position and open procedures resulting in longer operative times.9

ORTHOPEDIC SURGERY

Patients having major orthopedic surgery, including hip and knee arthroplasty and hip fracture repair, are considered to be at high risk of developing VTE. The rates of DVT in patients having surgery for injuries below the femur are poorly studied. Many of these patients have a decreased number of risk factors (eg, younger age, overall healthier status) compared to those having fractured femurs, thus reducing some of their risk factors.9

NEUROSURGERY

Patients undergoing neurosurgery (ie, non-spine) are considered to be in the moderate risk category for the development of postoperative VTE. Some of the risk factors for this population include decreased leg strength and the length of the operative procedure.9

TRAUMA, SPINAL CORD INJURY, BURNS

Trauma patients are at the highest risk (ie, greater than 50%) among hospitalized patients with a risk of having DVT. Pulmonary embolism is the third leading cause of death in those trauma patients who do not receive prophylaxis and who survive the first 24 hours after injury. Trauma patients with spinal cord injury are at greatest risk, with 60% to 100% reported as having DVT.9

Serious burns result in a patient with profound systemic hypercoagulability. This factor, combined with prolonged bed rest, multiple surgical procedures, femoral venous catheter insertion, and recurrent bouts of sepsis, increases the risk of DVT.9

MALIGNANCY

Venous thromboembolism is a common complication seen in patients with cancer, accounting for nearly 20% of all patients with a new VTE diagnosis. Comparing those with and without cancer, those with cancer have a sixfold increased risk of developing VTE. When a cancer patient has a surgical procedure, the risk of postoperative DVT is more than twice that of a noncancer
patient, and the risk of a fatal PE is more than three times that of a noncancer patient undergoing a similar procedure.9

**CRITICAL CARE**

Patients in a critical care setting have multiple risk factors for VTE (eg, recent surgery, trauma, sepsis, malignancy, immobilization, stroke, advanced age, heart or respiratory failure, previous VTE, and pregnancy), many occurring before the admission. The critical care patient also has additional risk factors such as immobilization, use of pharmacologic agents for paralysis or sedation, central venous access catheters, surgical procedures, sepsis, mechanical ventilation, vasopressor use, heart failure, renal dialysis, and depletion of endogenous anticoagulants during their stay in critical care unit.9

**NURSING PROCESS APPLICATION**

Application of the nursing process when caring for patients at risk for DVT or PE includes the use of the Perioperative Nursing Data Set (PNDS). The PNDS vocabulary is a clinically relevant and empirically validated standardized nursing language. It is related to the delivery of care in the perioperative setting. This standardized language consists of a collection of data elements and includes perioperative nursing diagnosis, interventions, and outcomes. In 1999, the American Nurses Association Committee on Nursing Practice recognized the PNDS information infrastructure as a data set useful in the practice of nursing.

The Perioperative Patient Focused Model provides the conceptual framework for the PNDS and the model for perioperative nursing practice.9 The patient and his or her family members are the core of the PNDS model. The model depicts perioperative nursing in four domains and illustrates the relationship between the patient, family members, and the care provided by the professional perioperative nurse. The patient-centered domains are:

- **D1** Safety
- **D2** Physiological Responses
- **D3-A** Behavioral Responses—Patient and Family: Knowledge
- **D3-B** Behavioral Responses—Patient and Family: Ethics
- **D4** Health System

A unique identifier represents each data element in the PNDS. Domains are represented by the letter “D,” followed by numbers one through four to indicate the particular domain being addressed. Nursing diagnoses are represented by the letter “X” and a number unique to the diagnosis. Interventions are represented by the letter “I” and a number. These designations are used in this document as appropriate. Desired outcomes are represented by the letter “O.”37

The following is a partial list of outcomes, nursing diagnoses, and interventions adapted from the PNDS vocabulary that may be associated with the individual with a potential for or having a diagnosis of venous stasis, DVT, or PE. The outcomes, nursing diagnosis, and interventions are grouped by domains.

<table>
<thead>
<tr>
<th>Domain/Outcome/Nursing Diagnosis/Interventions</th>
<th>Preop</th>
<th>Intraop</th>
<th>Postop</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DOMAIN 1: SAFETY</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O5</td>
<td>The patient is free from signs and symptoms of injury related to positioning.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X40</td>
<td>Perioperative positioning injury, risk for impairment of tissue perfusion, or length of surgical procedure.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X61</td>
<td>Tissue perfusion: Ineffective.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I77</td>
<td>Implements protective measures to prevent skin/tissue injury due to mechanical sources.</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>I64</td>
<td>Identifies physical alterations that require additional precautions for procedure-specific positioning.</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>I96</td>
<td>Positions the patient.</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>I38</td>
<td>Evaluates for signs and symptoms of injury as a result of positioning.</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>I152</td>
<td>Evaluates for signs and symptoms of physical injury to skin and tissue.</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>I138</td>
<td>Implements protective measures prior to operative or invasive procedure.</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>I77</td>
<td>Implements protective measures to prevent skin/tissue injury due to mechanical sources.</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>I15</td>
<td>Assesses factors related to risks for ineffective tissue perfusion.</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Domain/Outcome/Nursing Diagnosis/Interventions</td>
<td>Preop</td>
<td>Intraop</td>
<td>Postop</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>-------</td>
<td>---------</td>
<td>--------</td>
</tr>
<tr>
<td><strong>O9</strong> The patient receives appropriate medication(s), safely administered during the perioperative period.</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>X29 Injury, risk due to positioning and inadequate mobility.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I8 Administers prescribed medications and solutions.</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>I51 Evaluates response to medications.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DOMAIN 2: PHYSIOLOGIC</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>O11</strong> The patient has wound/tissue perfusion consistent with or improved from baseline levels established preoperatively.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X18 Fluid volume, risks related to inadequate circulation.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X28 Infection, risk of circulation or tissue perfusion.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I60 Identifies baseline tissue perfusion.</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>I15 Assesses factors related to risks for ineffective tissue perfusion.</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>I46 Evaluates postoperative tissue perfusion.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I3 Administers care to invasive device sites.</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>O14</strong> The patient’s respiratory function is consistent with or improved from baseline levels established preoperatively.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X7 Breathing pattern: Ineffective due to respiratory compromise.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X21 Gas exchange: Impaired due to inadequate respiratory exchange.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X55 Ventilation: Impaired spontaneous.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I87 Monitors changes in respiratory status.</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>I121 Uses monitoring equipment to assess respiratory status.</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>I110 Recognizes and reports deviation in arterial blood gas studies.</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>I45 Evaluates postoperative respiratory status.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>O15</strong> The patient's cardiovascular status is consistent with or improved from baseline levels established preoperatively.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X8 Cardiac output: Decreased related to impaired tissue perfusion.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X41 Peripheral neurovascular dysfunction: Risk for.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I59 Identifies baseline cardiac status.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I120 Uses monitoring equipment to assess cardiac status.</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>I44 Evaluates postoperative cardiac status.</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>O30</strong> The patient's neurological status is consistent with or improved from baseline levels established preoperatively.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X11 Confusion: Acute related to physiological conditions.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X1 Activity intolerance: Related to multiple conditional factors.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I111 Recognizes and reports deviations in diagnostic study results.</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>DOMAIN 3-A: BEHAVIORAL RESPONSES—PATIENT AND FAMILY: KNOWLEDGE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>O19</strong> The patient demonstrates knowledge of medication management.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X71 Health maintenance: Ineffective.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I104 Provides instruction about prescribed medications.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>O21</strong> The patient participates in the rehabilitation process.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X34 Physical modality: Impaired due to injury or disease process.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I106 Provides instructions based on age and identified needs.</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>I50 Evaluates response to instructions.</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
Additional interventions should be considered by the perioperative nurse when developing an individualized plan of care for the patient with a potential of venous stasis, DVT, or PE. Interventions should be selected according to the procedure to be performed, and they should address the potential prevention of venous stasis, DVT, or PE. The interventions below are grouped by location of care. Some of the interventions are repeated because this intervention should be carried out in all three areas. An intervention listed in only one area does not mean that it may not be appropriate for other areas depending upon the situation and the setting.38,39

**PREOPERATIVE.**
- Assess all patients to determine risk factors for venous stasis, DVT, or PE. Data collection involves patients and their significant others. A tool such as Table 1 or Appendix A may be used to classify the patient’s risk level. This risk level can be used in determining the appropriate method of prophylaxis.
- The choice of therapy is a medical decision, but the perioperative registered nurse should collaborate with surgeons, anesthesia care providers, and other health care professionals involved regarding initiating the established protocol orders for DVT or PE prevention.9
- If antiembolism stockings are the treatment of choice, the preoperative nurse should measure the patient for proper fit and apply as ordered. If applied incorrectly, stockings may cause DVT, arterial ischemia, gangrene, and necrosis and result in amputation by constricting blood flow. If the stockings roll down, there is the potential that a tourniquet effect will be created.31
- Ensure that IPC devices are applied properly, in a timely manner per manufacturer’s recommendation, if ordered.31
- Ensure that the devices do not hinder ambulation.9
- Ensure that prophylactic medications are given as ordered.9

**INTRAOPERATIVE.**
- Confirm that the antiembolism stockings and IPC devices are placed on the patient properly and that medications are given as ordered when performing the preoperative assessment.9,31
- After the patient is transferred to the OR bed, the IPC device should be turned on before the beginning of induction of general anesthesia or before regional anesthesia has been administered.1
- Instruct the surgical assistant or scrub nurse to avoid extreme degrees of flexion and internal rotation of hip and knee. Preventing endothelial damage due to abnormal leg positioning (eg, during hip surgery when the acetabular head is dislocated and the leg brought across the body, causing kinking of the femoral vein) is an important responsibility shared by the surgery team and the circulating nurse.28
- Be aware that unnecessarily high tourniquet pressures and prolonged periods of inflation should be avoided, if possible, when a tourniquet is used.28
- Avoid the reverse Trendelenburg position whenever possible because of a potential reduction in blood flow rate to the legs.28
- Check antiembolism stockings to ensure that they have not rolled down during movement to the OR bed or during positioning.31
- Ensure that the IPC devices work properly during the surgical procedure.31
- Continue the established protocol orders for DVT or PE prevention.9

**POSTOPERATIVE.**
- Ensure that the IPC devices do not hinder ambulation.9
- Ensure that the device is removed for only a very short period of time.1
- Ensure that the IPC device is turned on and working properly and confirm proper functioning and application with the nurse assuming care, if ordered.1
Instruct the patient in the importance of moving and ambulation in preventing postoperative complications per the surgeon’s postoperative orders.1

Continue the established protocol orders for DVT or PE prevention.9

Educate patients, caregivers, and health care professionals about prevention of DVT. Education should include common signs and symptoms such as leg pain, swelling, and unexplained shortness of breath.22

### TREATMENT AND PREVENTION

A protocol for the prevention of DVT or PE, detailing the primary and secondary prophylactic therapy methods, should be developed by each facility.22

### PRIMARY PREVENTION

Perioperative or primary prophylactic therapy in patients with risk factors for DVT or PE involves their prevention, if possible. If preventive measures are unsuccessful, the goal is to reduce the consequences of DVT or PE. The two main strategies are use of nonpharmacologic interventions and pharmacologic interventions. The Seventh American College of Chest Physicians Consensus Conference on Antithrombotic Therapy recommends that patients be classified as low, moderate, high, or very high risk for the development of DVT or PE, and that prophylactic regimens be used according to risk stratification. Examples of the recommended risk stratification are described in Table 1 and Appendix A.9 A protocol outlining the preventive measures to be taken for each risk classification should be

### Table 1

<table>
<thead>
<tr>
<th>Risk level</th>
<th>Surgical parameters</th>
<th>Prophylactics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Uncomplicated minor surgery in patients younger than 40</td>
<td>• Early and aggressive ambulation</td>
</tr>
<tr>
<td></td>
<td>years with no clinical risk factors requiring general</td>
<td>• No specific prophylaxis</td>
</tr>
<tr>
<td></td>
<td>anesthesia less than 30 minutes.</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>Surgical patients aged 40 to 60 years with no additional</td>
<td>• Low-dose unfractionated heparin every 12 hours</td>
</tr>
<tr>
<td></td>
<td>risk factors. Major surgery in patients younger than 40</td>
<td>• Low-molecular-weight heparin (&lt; 3,400 units daily)</td>
</tr>
<tr>
<td></td>
<td>years with no additional risk factors requiring general</td>
<td>• Graded compression stockings or intermittent</td>
</tr>
<tr>
<td></td>
<td>anesthesia longer than 30 minutes. Minor surgery in</td>
<td>pneumatic compression (IPC)</td>
</tr>
<tr>
<td></td>
<td>patients with risk factors.</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Major surgery in patients older than 60 years without</td>
<td>• Low-dose unfractionated heparin; 5,000 units</td>
</tr>
<tr>
<td></td>
<td>additional risk factors. Major surgery in patients aged</td>
<td>every 8 hours</td>
</tr>
<tr>
<td></td>
<td>40-60 years with additional risk factors. Patients with</td>
<td>• Low-molecular-weight heparin (&gt; 3,400 units</td>
</tr>
<tr>
<td></td>
<td>history of myocardial infarction. Medical patients with</td>
<td>daily); elastic stockings or IPC</td>
</tr>
<tr>
<td></td>
<td>risk factors.</td>
<td></td>
</tr>
<tr>
<td>Highest</td>
<td>Major surgery in patients older than 40 years with</td>
<td>• Low-molecular-weight heparin (&gt; 3,400 units</td>
</tr>
<tr>
<td></td>
<td>multiple risk factors (eg, prior venous thromboembolism,</td>
<td>daily); fondaparinux, oral vitamin K antagonists</td>
</tr>
<tr>
<td></td>
<td>malignant disease, hypercoagulable state). Patients with</td>
<td>(international normalized ratio 2-3); low-</td>
</tr>
<tr>
<td></td>
<td>elective major lower extremity orthopedic surgery, hip</td>
<td>molecular-weight heparin or low-</td>
</tr>
<tr>
<td></td>
<td>fracture, stroke, multiple trauma, or spinal cord injury.</td>
<td>molecular-weight heparin; IPC or graded</td>
</tr>
</tbody>
</table>
<pre><code>                            |                                                          | compression stockings.                             |
</code></pre>

developed by every health care organization.\textsuperscript{22} The pharmacologic and nonpharmacologic interventions can be used together or separately depending upon the patient’s risk classification.

**Nonpharmacologic Interventions.** Low-risk patients should receive nonpharmacologic prophylaxis during the perioperative period until ambulation can be initiated.\textsuperscript{20} These measures include elastic stockings, IPC devices, and early ambulation, and are especially useful when heparin therapy is contraindicated.

Compression stockings (either thigh-high length or calf-high length) frequently are used after surgery and during airplane rides to promote circulation.\textsuperscript{31} Compression stockings may be uncomfortable, but their effect on blood circulation helps to reduce the potential for DVT. Calf-length elastic stockings are effective for patients who undergo low-risk procedures and are relatively free of complications.\textsuperscript{1,20}

Intermittent pneumatic compression (IPC) is a nonpharmacologic prophylactic method used to reduce stasis and improve venous return from the lower extremities. Intermittent pneumatic compression is effective in patients with moderately high risk. Devices are available in various designs (eg, foot pumps [arteriovenous impulse system], intermittent uniform pneumatic compression).\textsuperscript{1,9}

Caution should be taken in using IPC on patients who have been on bed rest or immobilized for more than 72 hours because of the risk of disrupting newly formed clots.\textsuperscript{17,20} Contraindications for IPC include any local leg condition or venous flow compromise that the sleeves would interfere with, such as

- dermatitis,
- gangrene,
- severe arteriosclerosis or other ischemic vascular disease,
- massive leg edema,
- pulmonary edema with congestive heart failure,
- extreme leg deformity,
- preexisting deep vein thrombosis, and
- injuries or surgical sites located in the lower extremities.\textsuperscript{26,40}

Early ambulation is the most important and effective nonpharmacologic approach in the prevention of DVT and PE.\textsuperscript{3,14,20,38} Vena cava filters can be used in patients who cannot tolerate pharmacologic interventions or in those for whom alternative treatments have been unsuccessful. The primary limitation of these filters is that they become ineffective after one to two years.\textsuperscript{5}

**Pharmacologic Interventions.** Pharmacologic interventions are anticoagulant medications that inhibit the blood from clotting. The pharmacologic regimen consists of medications such as coumarin, synthetic pentasaccharide (ie, fondaparinux), low-molecular-weight heparin, and low-dose heparin. The route of administration is dependent on the medication. The platelet active drugs and coumarin are administered orally; heparin and fondaparinux are given by injection.\textsuperscript{43}

Complications of anticoagulant therapy include bleeding, hematoma formation, compartment syndrome, and heparin-induced thrombocytopenia. The bleeding may be major or minor. Major bleeding can include hemorrhage that alters the patient’s treatment or outcome.\textsuperscript{5}

Anticoagulant therapy is contraindicated in patients experiencing hemorrhage or with multiple traumas that are in an unstable condition, pregnancy, head trauma, or patients with a spinal catheter in place. Anticoagulants should be given with caution in patients with a history of cerebral or gastrointestinal hemorrhage, thrombocytopenia, or coagulopathy.\textsuperscript{5}

**Secondary Prevention**

Secondary prevention is screening of high-risk postoperative patients. This screening leads to the early detection and therefore timely treatment of subclinical DVT. This is particularly important in those patients in whom primary prophylaxis is either contraindicated or ineffective. Routine ultrasonography screening at discharge or during outpatient follow-up is not affordable or available in many facilities and therefore is not recommended in asymptomatic patients.\textsuperscript{3,38}

**Evaluation of Outcomes**

The perioperative nurse evaluates the patient’s progress toward attainment of outcomes. This evaluation should be systematic, ongoing, and documented using the PNDS.
Outcome indicators will vary according to specific patient outcomes. These indicators may include
- physiological indicators (e.g., cardiovascular status);
- cognitive indicators (e.g., asking appropriate questions);
- affective indicators (e.g., willingness to comply with treatment regimens); and
- supportive resources (e.g., family member participation in care planning and delivery).

**PATIENT SATISFACTION**

Evaluation of the patient’s progress is based on observation of the patient’s response to nursing interventions and the effectiveness of these interventions in moving the patient toward the preferred outcomes. Preferred patient outcomes, nursing interventions, and potentially applicable nursing diagnoses are articulated in the standardized perioperative nursing vocabulary, which provides the basis for documentation of perioperative nursing practice. Ongoing assessments should be used to revise diagnoses, outcomes, and the plan of care as needed. Revisions in diagnoses, outcomes, and the plan of care should be documented. The patient and his or her significant others, working in conjunction with the health care provider, should be involved in the process.

**QUALITY ASSESSMENT**

Health care organizations that develop a protocol should evaluate the protocol on a periodic basis. The protocol should be evaluated against current research and research-based established guidelines. The effectiveness of the protocol should be evaluated using information supplied by physicians and examination of records of postoperative readmissions for venous stasis or its complications.

**SUMMARY**

The assessment for patient risk and the prevention of DVT and PE are of prime importance in all patients. Assessment and prevention are especially important in the patient undergoing a surgical intervention. Perioperative nurses can use this document to increase their awareness of and skill at detecting patients at increased risk and to improve their skills in caring for these patients.

**REFERENCES**


Approved by the AORN Board of Directors, November 2006.
### APPENDIX A

**Venous Thromboembolism Risk Factor Assessment**

Patient’s Name ____________________________________  Age: ____  Sex: ____  Wgt: ____ lbs

<table>
<thead>
<tr>
<th>Each risk factor represents 1 point</th>
<th>Each risk factor represents 2 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Age 41–60 years</td>
<td>☐ Age 60–74 years</td>
</tr>
<tr>
<td>☐ Minor surgery planned</td>
<td>☐ Major surgery (&gt; 60 minutes)</td>
</tr>
<tr>
<td>☐ History of prior major surgery</td>
<td>☐ Arthroscopic surgery (&gt; 60 minutes)</td>
</tr>
<tr>
<td>☐ Varicose veins</td>
<td>☐ Laparoscopic surgery (&gt; 60 minutes)</td>
</tr>
<tr>
<td>☐ History of inflammatory bowel disease</td>
<td>☐ Previous malignancy</td>
</tr>
<tr>
<td>☐ Swollen legs (current)</td>
<td>☐ Central venous access</td>
</tr>
<tr>
<td>☐ Obesity (BMI &gt; 30)</td>
<td>☐ Morbid obesity (BMI &gt; 40)</td>
</tr>
<tr>
<td>☐ Acute myocardial infarction (&lt; 1 month)</td>
<td>☐ Elective major lower extremity arthroplasty</td>
</tr>
<tr>
<td>☐ Congestive heart failure (&lt; 1 month)</td>
<td>☐ Hip, pelvis, or leg fracture (&lt; 1 month)</td>
</tr>
<tr>
<td>☐ Sepsis (&lt; 1 month)</td>
<td>☐ Stroke (&lt; 1 month)</td>
</tr>
<tr>
<td>☐ Serious lung disease, including pneumonia (&lt; 1 month)</td>
<td>☐ Multiple trauma (&lt; 1 month)</td>
</tr>
<tr>
<td>☐ Abnormal pulmonary function (COPD)</td>
<td>☐ Acute spinal cord injury (paralysis) (&lt; 1 month)</td>
</tr>
<tr>
<td>☐ Medical patient currently at bed rest</td>
<td>☐ Major surgery lasting over 3 hours</td>
</tr>
<tr>
<td>☐ Leg plaster cast or brace</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Each risk factor represents 3 points</th>
<th>Choose all that apply</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Age over 75 years</td>
<td>☐ Oral contraceptives or hormone replacement therapy</td>
</tr>
<tr>
<td>☐ Major surgery lasting 2-3 hours</td>
<td>☐ Pregnancy or postpartum (&lt; 1 month)</td>
</tr>
<tr>
<td>☐ BMI &gt; 50 (venous stasis syndrome)</td>
<td>☐ History of unexplained stillborn infant, recurrent spontaneous abortion (= 3), premature birth with toxemia or growth-restricted infant</td>
</tr>
<tr>
<td>☐ History of SVT, DVT/PE</td>
<td>☐ Other thrombophilia</td>
</tr>
<tr>
<td>☐ Family history of DVT/PE</td>
<td>Total Risk Factor Score ____________________________</td>
</tr>
<tr>
<td>☐ Present cancer or chemotherapy</td>
<td>Type ________________________________</td>
</tr>
<tr>
<td>☐ Positive Factor V Leiden</td>
<td>Please see following page for prophylaxis safety considerations. Revised July 23, 2006</td>
</tr>
<tr>
<td>☐ Positive Prothrombin 20210A</td>
<td></td>
</tr>
<tr>
<td>☐ Elevated serum homocysteine</td>
<td></td>
</tr>
<tr>
<td>☐ Positive Lupus anticoagulant</td>
<td></td>
</tr>
<tr>
<td>☐ Elevated anticardiolipin antibodies</td>
<td></td>
</tr>
<tr>
<td>☐ Heparin-induced thrombocytopenia (HIT)</td>
<td></td>
</tr>
<tr>
<td>☐ Other thrombophilia</td>
<td></td>
</tr>
<tr>
<td>☐ Type ________________________________</td>
<td></td>
</tr>
</tbody>
</table>

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APPENDIX A, continued

Venous Thromboembolism Risk Factor Assessment

<table>
<thead>
<tr>
<th>Total Risk Factor Score</th>
<th>Incidence of DVT</th>
<th>Risk Level</th>
<th>Prophylaxis Regimen</th>
<th>Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>&lt; 10%</td>
<td>Low Risk</td>
<td>No specific measures; early ambulation</td>
<td>ES – Elastic Stockings</td>
</tr>
<tr>
<td>2</td>
<td>10-20%</td>
<td>Moderate Risk</td>
<td>ES, IPC, LDUH (5000 U BID), or LMWH (&lt; 3400 U)</td>
<td>IPC – Intermittent Pneumatic Compression</td>
</tr>
<tr>
<td>3-4</td>
<td>20-40%</td>
<td>High Risk</td>
<td>IPC, LDUH (5000 U TID), or LMWH (&gt; 3400 U)</td>
<td>LDUH – Low Dose Unfractionated Heparin</td>
</tr>
<tr>
<td>5 or more</td>
<td>40-80%, 1-5% mortality</td>
<td>Highest Risk</td>
<td>Pharmacological: LDUH, LMWH (&gt; 3400 U)<em>, Warfarin</em>, or FXaI* alone or in combination with ES or IPC</td>
<td>LMWH – Low Molecular Weight Heparin</td>
</tr>
</tbody>
</table>

*FXaI* – Factor X Inhibitor

Legend

ES – Elastic Stockings
IPC – Intermittent Pneumatic Compression
LDUH – Low Dose Unfractionated Heparin
LMWH – Low Molecular Weight Heparin
FXaI – Factor X Inhibitor

*Use for major orthopedic surgery

Prophylaxis Safety Considerations: Check Box If Answer Is “YES”

☐ Is patient experiencing any active bleeding?
☐ Does patient have (or has patient had history of) heparin-induced thrombocytopenia?
☐ Is patient’s platelet count < 100,000/mm3?
☐ Is patient taking oral anticoagulants, platelet inhibitors (eg, NSAIDS, Clopidogrel, Salicylates)?
☐ Is patient’s creatinine clearance abnormal? If yes, please indicate value _______________

If any of the above boxes are checked, the patient may not be a candidate for anticoagulant therapy and you should consider alternative prophylactic measures: elastic stockings and/or IPC.

Intermittent Pneumatic Compression (IPC)

☐ Does patient have severe peripheral arterial disease?
☐ Does patient have congestive heart failure?
☐ Does patient have an acute superficial/deep vein thrombosis?

If any of the above boxes are checked, then patient may not be a candidate for intermittent compression therapy and you should consider alternative prophylactic measures.

Examiner __________________ Date_____________________