



# Implementation Guide to Prevention of Venous Thromboembolism (VTE)

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# Prevention of Venous Thromboembolism (VTE) Overview



## Background:

- Pulmonary Embolus resulting from Deep Venous Thrombosis is the most common cause of preventable hospital death.
- A U.S. multi-center registry study showed the majority of hospitalized patients with risk factors for DVT did not receive prophylaxis.
- The risk for developing VTE varies between 10 - 85% (depending on reason for admission).
- The rate of fatal pulmonary embolus more than doubles between the ages of 50 and 80.

## Suggested AIM:

- Reduce the incidence of hospital-acquired VTE by 30% by December 31, 2013
- Increase the utilization of appropriate VTE prophylaxis in at-risk patients to 100% by December 31, 2013

## Potential Measures:

**Outcome:** Incidence of hospital-acquired VTE (number of VTE per 100 admissions); goal: reduce by 50% in one year.

Incidence of hospital-acquired VTE resulting in fatality (number of deaths due to acquired VTE per 100 admissions).

**Process:** Percent of patients screened on admission using VTE risk assessment tool

Compliance with appropriate VTE prophylaxis (percent of patients who should have received prophylaxis, whether screened or not, who actually received appropriate prophylaxis).

Note: "Hospital-acquired" includes the 30-day period post discharge

Primary Drivers	Secondary Drivers
Effective risk assessment	<ul style="list-style-type: none"> <li>✓ Adopt a VTE risk-assessment screening tool; simplify as much as possible.</li> <li>✓ Assess every patient upon admission of his/her risk for VTE using the VTE risk assessment screening tool.</li> </ul>
Develop best practices for prophylaxis	<ul style="list-style-type: none"> <li>✓ Review key resources and identify best practices.</li> <li>✓ Adopt a standardized risk-stratified menu of choices for prophylaxis; simplify as much as possible.</li> </ul>
Standardize care processes	<ul style="list-style-type: none"> <li>✓ Develop standard written order sets which link the risk assessment to the choice of prophylaxis.</li> <li>✓ Identify contraindications and include them in order sets.</li> <li>✓ Allow for 'opt-out' as clinically indicated.</li> </ul>
Decision support	<ul style="list-style-type: none"> <li>✓ Use protocols for dosing and monitoring.</li> </ul>
Involve the patient and family	<ul style="list-style-type: none"> <li>✓ Alert patients and families to early signs and symptoms of VTE.</li> <li>✓ Give clearly written and well explained VTE discharge instructions to patients and families.</li> <li>✓ Use 'read back' to demonstrate that patients and families have thorough understanding of dosing, physician and lab follow-up appointments.</li> </ul>

## Making Changes:

- This intervention is in the Collaborative with Reducing Pressure Ulcers and Falls (PIVOT Collaborative). National meetings, webinars, monthly coaching calls, change packages and other tools will augment state hospital association activities. The Collaborative will leverage the IHI Model for Improvement (Plan-Do-Study-Act).

## Key Resources:

- Executive Summary: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines *Chest February 2012 141:2\_suppl 7S-47S*
- Qaseem et al, Venous Thromboembolism Prophylaxis in Hospitalized Patients: A Clinical Practice Guideline From the American College of Physicians *Annals Internal Medicine 1 November 2011 155 (9):625-633*
- American College of Chest Physicians (ACCP). Prevention of venous thromboembolism. American College of Chest Physicians evidence-based clinical practice guidelines (8th edition). *Chest 2008 Jun;133(6 Suppl):381S-453S. [728 references]*
- American Academy of Orthopaedic Surgeons (AAOS). American Academy of Orthopaedic Surgeons clinical guideline on prevention of symptomatic pulmonary embolism in patients undergoing total hip or knee arthroplasty. Rosemont (IL): American Academy of Orthopaedic Surgeons (AAOS); 2007. 63 p. [49 references]
- Society of Hospital Medicine VTE Resource Guide:  
[http://www.hospitalmedicine.org/ResourceRoomRedesign/RR\\_VTE/VTE\\_Home.cfm](http://www.hospitalmedicine.org/ResourceRoomRedesign/RR_VTE/VTE_Home.cfm)
- AHRQ Prevention of VTE Following Hip and Knee Reconstruction Synthesis of Guidelines :  
<http://www.guideline.gov/syntheses/synthesis.aspx?id=16473>

# Prevention of Venous Thromboembolism (VTE) Driver Diagrams

2012-2013



**AIM: Reduce the Incidence of Hospital Acquired\*Venous Thromboembolic Events by 30% by 12/31/13**

**\*Includes events occurring within 30 days of discharge**

Primary Drivers	Secondary Drivers	Change Ideas
Effective Risk Stratification	<ul style="list-style-type: none"> <li>• Adopt effective and reliable risk assessment screening risk for VTE and bleeding <sup>1,2,3,4</sup></li> <li>• Develop mechanisms to ensure risk screening for all admitted patients</li> </ul>	<ul style="list-style-type: none"> <li>✓ Simplify to low, medium and high-risk levels that dictate different treatment options <sup>1,2,3,4</sup></li> <li>✓ Screen on admission and upon transfer to new level of care or condition change</li> </ul>
Standardized Care Process	<ul style="list-style-type: none"> <li>• Create a system for regular updates from the medical literature</li> <li>• Develop, adopt, and apply best practices to all patients</li> <li>• Develop standard order sets and protocols</li> <li>• Allow “opt-out” methodology where clinically appropriate</li> <li>• Develop ambulation protocols</li> </ul>	<ul style="list-style-type: none"> <li>✓ See key resources as starting point <sup>5,6,7,8,</sup></li> <li>✓ Develop standardized order sets with risk linked to appropriate prophylaxis.</li> <li>✓ Analyze use of order sets as overall process learning tool</li> <li>✓ Create a nurse/physical therapy directed progressive mobility protocol<sup>9</sup></li> </ul>
Decision Support	<ul style="list-style-type: none"> <li>• Monitor timeliness of administration practices</li> <li>• Use flow sheets that follow the patient through the transitions of care</li> <li>• Have pharmacist round concurrently with physicians</li> <li>• Use pharmacists to assist with identification of alternatives when contraindications exist</li> </ul>	<ul style="list-style-type: none"> <li>✓ Understand the current state: use sampling strategies to perform real time audits in various units whether on paper or EMR</li> <li>✓ Use validated tools to assess current knowledge of clinical staff regarding risk of anticoagulants <sup>10,11</sup></li> <li>✓ Pilot pharmacist participation on rounds in ICU or post-op orthopedics unit</li> <li>✓ Have pharmacists available to all clinical staff by immediate electronic device/method</li> </ul>
Prevention of Failure	<ul style="list-style-type: none"> <li>• Have pharmacists perform independent double checks of all VTE prophylaxis orders</li> </ul>	<ul style="list-style-type: none"> <li>✓ If on paper, have nursing fax all risk assessment and documentation of contraindications to pharmacy with VTE prophylaxis orders</li> </ul>

Primary Drivers	Secondary Drivers	Change Ideas
		<ul style="list-style-type: none"> <li>✓ If electronic, then risk assessment must be visible to pharmacist</li> <li>✓ Communication of risk and prophylaxis to the entire health care team including consulting physicians and nursing, e.g. place on nursing kardex to include VTE risk and prophylaxis.</li> <li>✓ If electronic, create hard stop for admitting and transferring physician to address risk and prophylaxis.</li> </ul>
Identification and Mitigation of Failure	<ul style="list-style-type: none"> <li>• Minimize or eliminate nurse distraction during medication administration process</li> <li>• Standardize concentrations and minimize dosing options where feasible</li> <li>• Timely lab results with effective system to ensure review and action</li> <li>• Use non-pharmacological methods of pain and anxiety management where appropriate</li> <li>• Identify “look-alike, sound-alike” medications and create a mechanism to reduce errors (e.g., different locations, labels, alternate packaging)</li> </ul>	<ul style="list-style-type: none"> <li>✓ Perform independent double checks</li> <li>✓ Use the “cone of silence” during medication administration</li> <li>✓ Use visual cues like HAM specific flags at bedside</li> <li>✓ <b>INSULIN:</b> Allow patient management of insulin where appropriate</li> <li>✓ <b>INSULIN:</b> Set limits on high dose orders</li> <li>✓ <b>ANTICOAGULANTS:</b> Use prepackaged heparin infusions; reduce the number of heparin concentrations in the hospital</li> <li>✓ <b>ANTICOAGULANTS:</b> Use low molecular weight heparin instead of unfractionated heparin whenever clinically appropriate</li> <li>✓ <b>ANTICOAGULANTS:</b> Make lab results available within two hours</li> <li>✓ <b>ANTICOAGULANTS:</b> Perform automatic nutrition consults for all patients on warfarin to avoid drug-food interactions</li> <li>✓ <b>NARCOTICS/SEDATIVES:</b> Use a table of drug to drug conversion doses</li> <li>✓ <b>NARCOTICS/SEDATIVES:</b> Use fall prevention programs</li> <li>✓ <b>NARCOTICS/SEDATIVES:</b> Use dosing limits</li> </ul>
Smart Use of Technology	<ul style="list-style-type: none"> <li>• Educate patients/families regarding risk of ADEs from ‘their’ HAMs</li> <li>• Administer medications on time</li> <li>• Analyze dispensing unit override patterns</li> <li>• Transition to “just culture” environment for improved error analysis</li> <li>• Prompt real time learning from each failure</li> </ul>	<ul style="list-style-type: none"> <li>✓ Monitor, understand, and mitigate medication administration delays</li> <li>✓ Assess culture with Agency for Healthcare Research and Quality Culture of Safety survey <sup>11</sup></li> <li>✓ Use error reporting system to allow aggregate learning to redesign error prone processes</li> <li>✓ Use technology to alert (real time) key staff when rescue drug administered</li> </ul>

**Footnotes:**

- <sup>1</sup> Rogers et al, J Am Coll Surg 2007;204:1211–1221 (see page 1219 for risk scoring tool)
- <sup>2</sup> Caprini, Joseph, VTE Risk Factor Assessment Tool [http://www.crmhealthcare.net/docs/67450a\\_CapriniRiskAssesemntTool.pdf](http://www.crmhealthcare.net/docs/67450a_CapriniRiskAssesemntTool.pdf)
- <sup>3</sup> Geerts, WH et al, CHEST **June 2008** vol. 133 no. 6 suppl **381S-453S** [http://chestjournal.chestpubs.org/content/133/6\\_suppl/381S.full](http://chestjournal.chestpubs.org/content/133/6_suppl/381S.full)
- <sup>4</sup> Geerts, WH, Texas SCIP Webex, 28 March, 2007 (pdf)
- <sup>5</sup> Guyatt et al, Executive Summary: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines *Chest February 2012 141:2\_suppl 7S-47S*
- <sup>6</sup> American Academy of Orthopaedic Surgeons (AAOS). American Academy of Orthopaedic Surgeons clinical guideline on prevention of symptomatic pulmonary embolism in patients undergoing total hip or knee arthroplasty. Rosemont (IL): American Academy of Orthopaedic Surgeons (AAOS); 2007. 63 p. [49 references]
- <sup>7</sup> [Society of Hospital Medicine VTE Resource Guide](#)
- <sup>8</sup> [AHRQ Prevention of VTE Following Hip and Knee Reconstruction Synthesis of Guidelines](#)
- <sup>9</sup> Timmerman, Rosemary, A Mobility Protocol for Critically Ill Adults, Dimensions of Critical Care Nursing Vol. 26 / No. 5, September/October 2007: 175-179 [http://www0.sun.ac.za/Physiotherapy\\_ICU\\_algorithm/Documentation/Rehabilitation/References/Timmerman\\_2007.pdf](http://www0.sun.ac.za/Physiotherapy_ICU_algorithm/Documentation/Rehabilitation/References/Timmerman_2007.pdf)
- <sup>10</sup> Hsaio et al, Nurses' knowledge of high-alert medications: instrument development and validation, Journal of Advanced Nursing 66(1), 177-190
- <sup>11</sup> Lu, M.-C. et al, Nurses' knowledge of high-alert medications, A randomized controlled trial, Nurse Educ. Today (2011)

## Prevention of Venous Thromboembolism (VTE)

VTE includes pulmonary embolism (PE) and deep vein thrombosis (DVT). VTE is the most common preventable cause of hospital death.<sup>1,2,3</sup>

Fortunately, pharmacologic and mechanical methods to prevent VTE are safe, cost-effective and advocated by authoritative guidelines.<sup>4</sup> Yet, despite the reality that hospitalized medical and surgical patients routinely have multiple risk factors for VTE, making the risk for VTE nearly universal among inpatients, large prospective studies continue to demonstrate that these preventive methods are significantly underutilized.<sup>5,6,7,8,9,10</sup>

The Agency for Healthcare Research and Quality calls thromboprophylaxis against VTE the “number one” patient safety practice. The American Public Health Association has stated that the “disconnect between evidence and execution as it relates to DVT prevention amounts to a public health crisis.”<sup>11</sup>

The following statements reflect best practice statements from the American College of Chest Physicians (ACCP) and the American Academy of Orthopaedic Surgeons (AAOS).

- In medical patients, low-molecular-weight heparins (LMWH), enoxaparin and dalteparin have efficacy comparable to subcutaneous heparin three times daily (SQ Heparin), but offers lower complication rates and other advantages potentially important to patients and nursing.<sup>12,13,14,15</sup>
- In certain higher risk patient groups (e.g. hip and knee replacement, trauma, and spinal cord injury) LMWH, *in some studies*, has demonstrated superiority over SQ heparin and fondaparinux.<sup>4,16,17,18,19,20</sup>
- Controversy exists with regard to the hip and knee replacement patients. The ACCP prefers LMWH<sup>16</sup> while the AAOS states that there is not enough evidence to recommend one form of pharmacologic prophylaxis over another.<sup>21</sup>
- In certain patient groups, extending prophylaxis with LMWH to approximately four to five weeks may be more effective than one week (e.g. hip replacement, surgery for cancer, and possibly medical patients with reduced mobility). The AAOS states that there is not enough evidence and that such extension should be individualized.<sup>4,21,22</sup>
- In certain patient groups, the adequacy of twice daily SQ heparin has not been proven.<sup>4</sup>
- In very high-risk patient groups, the addition of mechanical prophylaxis to a pharmacologic regimen may offer added benefit. The AAOS recommends this combination therapy in hip or knee replacement patients who have a history of prior VTE.<sup>4,21</sup>
- Certain patient groups should not receive certain pharmacologic agents or doses, or receive smaller doses of LMWH (e.g. creatinine clearance < 30 cc/minute) i.e. elderly, impaired renal and/or hepatic function.<sup>4</sup>
- Certain patient groups should receive pharmacologic doses in close coordination and timing with other events (e.g. surgery).

The clear messages from the literature are that:

1. VTE is common among both medical and surgical hospitalized patients.<sup>10</sup>
2. Fifty percent or more of VTE are preventable.<sup>10</sup>
3. Ten percent of VTE events can result in fatal pulmonary embolus, the most common preventable cause of hospital death.<sup>10</sup>
4. Complex assessment models are logistically difficult to incorporate into workflows and typically associated with suboptimal compliance.<sup>4,10,16</sup>
5. Complex assessment models do not confidently identify patients who do not require prophylaxis or predict how risk factors combine to position an individual patient along the spectrum of VTE risk.<sup>4,10,16</sup>

Therefore simple risk assessment models that stratify all patients into three to four easy to understand groups are favored over more complicated point scoring systems.<sup>10</sup>

## Suggested AIMS

- Reduce the incidence of hospital-acquired VTE by 30% by 12/31/2013
- Increase the utilization of appropriate VTE prophylaxis in at-risk patients to 100% by 12/31/2013

## Effective Risk Stratification

Effective risk stratification allows for the development of standardized processes that can drive more effective prophylaxis. Employing the simplest risk stratification makes this process easier to accomplish and more likely to be reliably applied. Although simple, this approach does not reduce the effectiveness of the therapeutic alternatives for patients.

### Secondary Driver: Adopt a risk-assessment screening system

Adopt a risk-assessment screening tool that is easy to complete and embed it into the workflow. More complex tools create extra work, creating reliability and sustainability problems, with limited changes to the therapeutic approach.

### Secondary Driver: Risk screen all admitted patients.

Develop a VTE risk-screening tool and determine when and by whom it will be completed.

### Secondary Driver: Repeat risk screening for patients on change of condition.

Repeating risk-screening for VTE prophylaxis or the appropriateness of therapy is important as a patient's condition changes. For example, a patient may have had contraindications for anti-coagulation because of a surgery or injury. As he/she have recovered and moves to a lower level of care anticoagulant therapy may have become indicated rather than contraindicated. Conversely a patient status could worsen such that different levels of thromboprophylaxis are now indicated. An example would be adding mechanical or anticoagulant prophylaxis to create combination therapy in a complicated post-operative surgery patient.

### Change Ideas:

- Screen on admission and upon transfer to new level of care or condition change.
- Link risk screen to another process such as medication reconciliation.
- Select a tool that segments patients and provides for associated treatment options<sup>23</sup>

### Suggested Process Measures

- The percent of patients who receive screening upon admission
- The percent of patients who receive screening upon transfer
- The percent of patients who develop VTE and are not on prophylaxis

### “Hardwiring” Effective Risk Stratification as part of improvement plan:

As suggested above, tie the screening to a trigger; the trigger could be admission orders (physician, nurse or pharmacist), the transfer orders, or medication reconciliation at each step. Create a “soft stop” in an electronic medical record, or by policy with paper records to add independent reassessment by the pharmacist of any patient screened as low risk (any patient admitted who does not receive VTE prophylaxis orders within a specific period of time). This will counter the tendency based on past practice to underestimate the risk of VTE in hospitalized patients. Finally, determining who performs the risk-stratification and how the is communicated to the entire team promotes sustainability.

## Standardized Care Processes

Standardized processes provide for more reliable care. They ensure that every patient gets evaluated and treated using standard tools. The use of these tools is linked to triggers, such as admission, or transfer, or time of operative intervention.

### Secondary Drivers: Create a system for regular updates from the medical literature.

Use the pharmacy & therapeutics committee or other designated committee of the medical staff to oversee periodic review of medical literature and protocols that contain medications.

### Secondary Driver: Develop standard VTE order sets and protocols.

“Standard work” assures that by default the patient gets the agreed upon standard of care, *unless the patient is known to have a condition that would dictate alternate care*. Order sets are one regimen to produce standard work but only offer a limited set of choices that may need adaptations for patients with special circumstances. Order sets improve standardization by reducing the need to remember all aspects of care.

### Secondary Driver: Allow “opt out” methodology where clinically appropriate.

Reliability theory has demonstrated that an “opt-out” approach, where a physician must specifically remove a portion of the order set and usually identify a reason why, can, in certain circumstances, lead to better outcomes. Analysis of these “opt out” orders where utilized and the reason given can lead to one of several improvements: 1) it can show where there are opportunities to improve the standard process; 2) it can lead to opportunities to educate the clinicians as to best practices, and 3) it can make it apparent that certain uncommon or complex conditions are more suitable for clinician care that is not driven by standard work.

### Secondary Driver: Develop ambulation protocols

Reduced mobility is a risk factor for the development of VTE. Putting a process into place that assesses a patient’s mobility and generates a recommendation for physical therapy referral will enable staff to safely mobilize patients. Nurse driven mobility protocols have demonstrated to be effective in reducing immobility related complications and reducing length of stay.<sup>23 24</sup>

#### Change Ideas:

- Start with the key literature references that summarize current best practices.<sup>10,16,25,26</sup>
- Use the ISMP newsletters and national references to stay abreast of the literature; assign specific staff the responsibility.
- Develop standardized order sets. See Appendix I for an example. Risk should be linked to appropriate prophylaxis in the order set.
- List most common reasons for ‘opt-out’ on order sheet for easy documentation and analysis.
- As spread is occurring, analyze the opt-out reasons on a regular basis to help improve the order set or educate the late adopters.
- Create a nurse/physical therapy directed progressive mobility protocol.<sup>27</sup>

#### Suggested Process Measures

- The percent of patients who are moderate or high risk based and have VTE prophylaxis ordered
- The percent of patients who receive the correct form of VTE prophylaxis

### “Hardwiring” Standardized Care Processes as part of improvement plan:

If your orders are on paper, create one form on a single page that serves as both a risk assessment form and a prophylaxis order form. The risk assessment should drive the prophylaxis order. If electronic, design the system so the risk assessment drives the appropriate prophylaxis. The order form should also list the most common reasons for alternate therapy. This allows the physician to document his or her thinking on the order form. It also allows for simplified data aggregation that promotes rapid learning.

## Decision Support

“Active” decision support has been shown to improve clinical practices and patient care. Decision support is often divided into active versus passive.

“Active” decision support occurs when a prompt is given to the caregiver suggesting the best practice based on other knowledge in the system about the patient. This can be in paper form, as discussed above, with a risk stratification tool linked to an order set on the same one-page paper. An essential part of an electronic medical record (EMR) is the use of logic to assess the patient’s individual clinical information that is present in the system, and based on provider approved best practices, notify clinicians of the recommended care path in real time. These are usually recommendations only, as the logic in the system cannot possibly represent all possible combinations of patient factors. In the case of VTE this would represent the order set automatically being prompted based on the risk assessment that had been entered in the system.

“Passive” decision support occurs when clinicians are offered resources that they can query when they choose to regard a specific patient condition or medication. Because this is voluntarily and not “in your face” it has not been shown to effectively change clinician practices enough to improve overall patient safety.

### **Secondary Drivers: Use flow sheets that follow the patient through the transitions of care.**

Medication administration flow sheets for anticoagulants should follow the patient from unit to unit and not be owned or kept by that unit once the patient is transferred. The lack of information continuity during the handoff can lead to errors during transition of care.

### **Secondary Driver: Have a pharmacist available on units as part of care team.**

Experience has shown that when clinical pharmacists are available on the units and round as part of the care team, the team is more likely to utilize the pharmacist’s knowledge and experience, improving the decision-making and reducing errors. To optimize the resource outlay of clinical pharmacists, target areas in the hospital where medication intensity is high and errors are more common.

### **Secondary Driver: Use pharmacists to identify alternatives when contraindications exist.**

When a patient has a contraindication to standard therapy, the decision-making can become quite complex. Consulting a clinical pharmacist can improve the ultimate decision-making regarding prophylaxis and potentially dosing.

#### ***Change Ideas:***

- Understand the current state: use sampling strategies to perform real time audits in various units whether on paper or EMR.
- Use validated tools to assess current knowledge of clinical staff regarding risk of anticoagulants.<sup>28,29</sup>
- Pilot pharmacist participation on rounds in ICU or post-op orthopedics unit.
- Have pharmacists available to all clinical staff by immediate electronic device/method.

#### ***Suggested Process Measures***

- The number of consultation requests that the clinical pharmacist receives
- The number of prophylactic anticoagulant orders that were modified as a result of pharmacist consultation

### **“Hardwiring” decision support as part of improvement plan:**

Try adding the pharmacist phone or pager in an obvious place in the “opt-out” section of the order set.

## Prevention of Failure

According to reliability theory principles, processes to prevent failure, supported by processes to identify and mitigate failure early, provide the best opportunities to provide reliable, effective and safe care. The following are some strategies and change ideas that have worked for some organizations.

### **Secondary Driver: Independent double checks of all VTE prophylaxis orders**

Independent double checks occur when one clinician double checks the work of another. It recognizes “human factors”; we are not perfect and as humans we make mistakes. Assuming that clinicians never make mistakes leads to predictable error. Use of the pharmacist to review VTE prophylaxis orders help ensure that order errors (drug, dose, frequency, and route) do not occur.

#### ***Change Ideas:***

- If on paper, have nursing fax all risk assessment and documentation of contraindications to pharmacy with VTE prophylaxis orders; if electronic, then the risk assessment must be visible to pharmacist along with the medication orders.
- The above processes allow the pharmacist to double check the appropriateness of the order based on medical staff policy and correctness and completeness of the order.
- Communicate each patient’s VTE risk and prophylaxis to the entire health care team including consulting physicians, nurses, physical therapists (e.g. place where all members of the healthcare team have access).
- Create process “stops” at admission and transfer that requires the appropriate clinician to acknowledge and address VTE risk and prophylaxis.

#### ***Suggested Process Measures***

- The percent of “opt-out” orders that are sent to the pharmacist
- The percent of patients with VTE prophylaxis orders that are changed at transfer to a different level of care
- The percent of moderate or high risk patients without VTE prophylaxis orders

### **“Hardwiring” prevention of failure as part of improvement plan:**

Create process “stops” in workflows that require pharmacy review of orders and clinician review and re-review of risk and prophylaxis orders upon admission and transfer to a different level of care.

## **Identification and Mitigation of Failure**

It is very difficult to design a system that prevents failure at all times. Early identification and mitigation of failure when it does occur is a central part of reliable processes.

### **Secondary Driver: Educate patients and families**

Education of the patients and families regarding the risk of VTE, bleeding and other complications can both help prevent as well as mitigate failures when they occur. The patient or family member may be the first to become aware of the signs of a complication of anti-coagulation, the side effects of mechanical prophylaxis, or the signs and symptoms of VTE. If they are unaware of the significance of these signs and symptoms they may not share this observation with the healthcare team. In addition, creating an environment where the patient or family feels comfortable asking questions and raising issues to clinicians promotes good communication and patient safety.

### **Secondary Driver: Utilize protocols for anticoagulation.**

One of the causes of delays in treating over or under coagulation is that without appropriate medical staff policies the nurse and pharmacist cannot respond in a timely manner. Instead of being able to stop the anti-coagulation, give reversal agents, or increase dose, they may instead spend time trying to reach the treating physician, all while the patient continues to be at further risk.

#### ***Change Ideas:***

- Allow nursing to hold heparin or administer Vitamin K via approved protocol based on the most recent lab value.

- Allow pharmacists via approved protocol to adjust unfractionated heparin and warfarin based on current lab values.
- Involve patients and families in the design of patient education materials.

### ***Suggested Process Measures***

- The number of out of range lab values in one week for patients receiving prophylactic anticoagulation
- The number of patients who are able to verbalize the warning signs of their treatment and what they need to do should they occur

### **“Hardwiring” identification and mitigation of failure as part of improvement plan:**

Create and approve medical staff policies that allow pharmacists and nurses, in certain situations, to stop or adjust coagulation doses based on the most recent lab values without contacting the physician first. Develop a “closed-loop” system for critical values that identifies all steps to rectify the problem and ensure it is managed appropriately. Periodically audit the process to ensure it is functioning as a closed-loop.

## **Smart Use of Technology**

Technology, used smartly, can drive improvement. Technology must be designed and implemented in a way that is consistent with human thinking and human workflows, while at the same time eliminating or mitigating common sources of human error.

### **Secondary Driver: Link order set to risk stratification tool.**

This is perfectly suitable for the smart use of technology. When the clinician completes risk stratification, the technology automatically leads the clinician to the recommended choices of orders for that risk stratification.

### **Secondary Driver: Link order set to recent lab values.**

Based upon approved medical staff policies and procedures, laboratory results can prompt the clinicians to alter the therapy. For example, with a medical staff policy that allows the nurse or pharmacist to alter an anticoagulant dose if a specific lab test is outside of accepted range, the drug can be immediately reduced or stopped, preventing or mitigating harm.

### **Secondary Driver: Use alerts but understand alert fatigue, roles of soft and hard stops.**

Alerts can be useful, but if overused for less important and more trivial issues, they will be ignored. This undesired result is alert fatigue.

### **Secondary Driver: Use alerts for weight based dosing for heparin.**

Some protocols dose heparin by weight. While slightly more complicated, weight based dosing can be more effective, particularly in populations with widely varying BMIs. The electronic record can easily prompt recommended dosing by using the entered patient weight. This also allows the pharmacist to double check the dose.

### **Secondary Driver: Real time, monitor and mitigate medication administration timing.**

Electronic medication administration tools allow charge nurses and pharmacists to run real-time reports regarding delayed administration of medications. Delayed administration or missed doses of an anticoagulant could have significant consequences for the patient. Catching and mitigating these delays in real time can improve the efficacy of prophylaxis. In addition, analyzing the data may lead to insights that promote changes in the systems of medication delivery that, over time, decrease the incidence of delays

**Secondary Driver: Use “smart pumps” to minimize dosing errors.**

Smart pumps can alert clinicians to potentially unsafe drug therapy prior to drug administration. The smart pump is designed to fuse traditional infusion-pump technology with predetermined clinical guidelines and IV drug administration protocols. If the program choices are outside a designated range, the pump sounds an alarm, indicating a “hard stop” or “soft stop” warning. A soft stop allows the infusion to continue without the need for dosing choices to be reentered. With a hard stop, choices must be reprogrammed according to pre-approved dosing guidelines.

**Change Ideas:**

- Capture accurate weights on all patients on prophylaxis.
- Pharmacy receives patient weight with VTE prophylaxis order.
- Use proper level (think seriousness or significance!) of alerts with forcing functions, stops, acknowledgement and drop down opt-out list for drug, allergy and diagnosis interactions.
- Use EMR real time reports to send electronic alerts when dosing occurs outside specified window.

**Suggested Process Measures**

- The percent of patients stratified to moderate or high-risk that receives appropriate prophylaxis orders

**“Hardwiring” smart use of technology as part of improvement plan:**

The challenge is to hardwire these electronic processes into the clinical processes. If the processes are ignored then safety opportunities are lost. There are many reports of numerous workarounds by staff using the electronic bedside medication verification method. This obviates the effectiveness of the built in safety intelligence. Again, the appropriateness of alert levels is key. If the intelligence of electronics is not germane to the clinician acting at the point of care then the value of electronics will be lost for these specific alerts. To compound the danger, conditioning may cause the clinician to ignore other sources of intelligence support of as well.

**Potential Barriers**

- Recognize that for some physicians this will be a change in their practice. Traditionally all clinicians have underestimated VTE risk. Physicians may resist pharmacist input regarding anti-coagulation. Some physicians may not be used to consulting pharmacists. As a result they may be unaware of what the organization’s pharmacists’ experience and knowledge is regarding VTE prophylaxis. Targeted modalities of education to the physician staff may be necessary for adoption to occur.
- Some physicians may be uncomfortable with pharmacists reviewing orders. Physician and pharmacist education, supported by approved medical staff policy that delineates the pharmacist’s latitude and communication back to the ordering physician will help overcome these barriers.
- Clinicians may resist a process stop that requires reassessment of VTE risk at transfer to a different level of care. Education and academic detailing by physician champions is key. In addition, dissemination of stories of early successes, where the stop resulted in appropriate changes of VTE risk and prophylaxis that might otherwise not have occurred, is often very helpful.
- Technology can become burdensome. It is important to use technology intelligently.
- Some clinicians may resist adoption because the process is too complicated. Facilitate adoption of VTE protocol/order set by anticipating the common reasons for contraindications and make those opportunities clear on the order forms. Make sure that the factors you adopt as contraindications are supported by current evidence.
- These processes will be new territory not only for physicians, but also for many nurses and pharmacists. Nurses and pharmacists may be concerned that they may make a mistake, that they are not adequately trained to follow the policy, or that the medical staff will not be receptive and may become angry.

Education of all parties, both about the risk of delayed intervention coupled with the efficacy of immediate intervention will help mitigate this. Using the concept of “first line responder” may help cross these hurdles.

Use administrative leadership and sponsorship to help remove or mitigate barriers:

- Implementing VTE reduction practices changes will require strong physician, pharmacy and nursing champions, often from each area in the hospital that is affected.
- A management executive sponsor, recognizing the value to the patients and the value to the organization of preventing VTE and its complications, can help brainstorm solutions to what may appear to be added work, or provide resources to mitigate that additional work.
- Senior physician, senior nursing and senior pharmacy management will be critical to the success of new innovations. These may be perceived as something punitive (timeliness audits), something new and unfamiliar (consult a pharmacist?), or additional work (cover the floors too?) Executive sponsors can help educate, lead, and provide solutions to staffing barriers.

This is not just a change in practice but may also be a change in culture:

- This may very well require a change in culture, particularly physician culture. The physicians will be asked to trade their traditional way of individualizing both risk assessment and prophylaxis for each patient for a more standardized and effective approach. This may appear to be both a loss of control as well as irresponsible to give up that control.
- Order sets may make some physicians uncomfortable who are not used to them. This will be a change in how they work. Physicians learn from peers. Most physicians will follow their peers before they will follow “expert advice.”
- Some physicians are not used to consulting pharmacists for treatment decisions. They will often be unaware of what the pharmacist has to offer. This is a good example of an innovation that will require small tests of changes and planned spread driven by success.

### **Tips for How to Use the Model for Improvement:**

- Tips on identifying barriers to timely anticoagulant administration:
  - Design and conduct a very quick assessment of the last 20 doses of anticoagulants on VTE patients.
- Tips on mitigation of error:
  - Look at data or listen to stories about how long it takes at times to contact the physician to get orders changed when lab results are out of range, along with any patient safety consequences of these delays.
- Tips for developing and implementing risk stratification and VTE prophylaxis order sets:
  - Ask one or two of the physicians on the committee to trial this with their next three admissions and start in one unit.
  - Reconvene and huddle after these trials and see if your tool needs to be modified.
  - Order sets: Design a small pilot on the unit where the lead physicians and nurses are comfortable with testing this innovation.
    - Try it with a few patients, possibly setting the out of range orders more extreme than what might be ideal based on the literature.
    - For example, you might start by allowing nurses or pharmacists to stop warfarin when the INR >6.0. Once the team achieves comfort, familiarity, and confidence, and experiences success, you can begin to lower the INR at which they can act.

**APPENDIX I: SIMPLIFIED VTE PROPHYLAXIS 2012** <sup>10,16,21,26,30</sup>**Principles:**

- Sensible prophylaxis works in moderate-risk and high-risk patients.
- Bleeding concerns are overestimated.
- The prophylaxis protocols must become a routine part of the patient care culture.
- Every hospital should develop a formal strategy that addresses the prevention of VTE's
- Simple works:
  - If not simple, opportunities will be missed and errors are more likely to occur.
  - When prophylaxis methods are equivalent, choose the method that simplifies the overall approach.
- Recognize that clinically acceptable alternatives exist.

**Recommendations: (normal bleeding risk)**

VTE Risk: Low	Medical: fully mobile, brief admission Surgical: procedure <45 minutes, mobile	No specific prophylaxis Early mobilization
VTE Risk: Moderate	Medical: bed rest, sick Surgical: major general, urologic or gynecologic procedures	LMWH (Grade 1A) <sup>i</sup> Start post-op Continue until discharge
VTE Risk: High <sup>ii</sup>	Major orthopedics <sup>iii</sup> Major trauma	LMWH <sup>iv</sup> Continue for up to 35 days (Grade 2B) THR, TKR: Start 12 hours pre-op (Grade 1B) HFS: Start >4 hours pre-op if surgery delayed

<sup>i</sup> LDUH is also Grade 1A<sup>16</sup>

<sup>i</sup> Addition of mechanical prophylaxis to LMWH in patients at high risk for VTE may be beneficial (Grade 2C)<sup>16</sup>

<sup>iii</sup> The AAOS states there is not enough evidence to distinguish between pharmacologic prophylaxis options.<sup>21</sup>

<sup>iv</sup> The ACCP states that Fondaparinux and LDUH are now Grade 2B.<sup>16</sup> The AAOS states there is not enough evidence to distinguish between pharmacologic prophylaxis options.<sup>21</sup>

**Recommendations: high bleeding risk:**

Active bleeding Known major bleeding disorder Platelet count <50,000 Intracranial bleeding in prior five days All neurological and spinal surgeries Heparin induced thrombocytopenia	Use mechanical prophylaxis, preferably IPC (Grade 2C) Re-evaluate and add LMWH when bleeding risk subsides. (Grade 2C)
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**Notes:**

- Inferior vena cava filters are not indicated for VTE prophylaxis and will increase DVT risk.
- Routine calf ultrasound surveillance for DVT not indicated.
- IPC's generally preferred to GCS's but may be tolerated less, have lower compliance by patients and staff, and be more costly. Calf length preferred because of better compliance and fewer infections.

**Abbreviations used:**

GCS	Graduated compression stockings	LMWH	Low molecular weight heparin
HFS	Hip fracture surgery	THR	Total hip replacement
IPC	Intermittent pneumatic compression	TKR	Total knee replacement
LDUH	Low density unfractionated heparin	VTE	Venous thromboembolic events

## References

- <sup>1</sup> Heit JA, O'Fallon WM, Petterson TM, et al. Relative impact of risk factors for deep vein thrombosis and pulmonary embolism, Arch Intern Med, 2002;162:1245-1248.
- <sup>2</sup> Tapson VF, Hyers TM, Waldo AL, et al. Antithrombotic therapy practices in US hospitals in an era of practice guidelines, Arch Intern Med, 2005;165:1458-1464.
- <sup>3</sup> Clagett GP, Anderson FA, Heit JA, et al. Prevention of venous thromboembolism, Chest, 1995;108:312-334.
- <sup>4</sup> Geerts WH, Pineo GF, Heit JA, et al. Prevention of venous thromboembolism: the Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy. Chest 2004;126(3 Suppl):338S-400S.
- <sup>5</sup> Goldhaber SZ, Tapson VF. A prospective registry of 5,451 patients with ultrasound-confirmed deep vein thrombosis. Am J Cardiol 2004;93:259-62.
- <sup>6</sup> Monreal M, Kakkar A, Caprini J, et al. The outcome after treatment of venous thromboembolism is different in surgical and acutely ill medical patients. Findings from the RIETE registry. J Thromb Haemost 2004;2:1892-8
- <sup>7</sup> Tapson V, Decousus H, Pini M, et al. Venous thromboembolism prophylaxis in acutely ill hospitalized medical patients: findings from the International Medical Prevention Registry on Venous Thromboembolism. Chest, 2007 Sep;132(3):936-45. Epub 2007 Jun 15.
- <sup>8</sup> Kahn SR, Panju A, Geerts W, et al. Multicenter evaluation of the use of venous thromboembolism prophylaxis in acutely ill medical patients in Canada. Thromb Res. 2007;119(2):145-55. Epub 2006 Mar 3.
- <sup>9</sup> Cohen AT, Tapson VF, Bergmann JF, et al. Venous thromboembolism risk and prophylaxis in the acute hospital care setting (ENDORSE study): a multinational cross-sectional study. Lancet. 2008 Feb 2;371(9610):387-94.
- <sup>10</sup> Maynard, Greg. Preventing Hospital-Acquired Venous Thromboembolism *A Guide for Effective Quality Improvement Version 3.3* Society of Hospital Medicine: Accessed March 6, 2012: [http://www.hospitalmedicine.org/ResourceRoomRedesign/RR\\_VTE/PDFs/VTEPreventionGuidev3.3.pdf](http://www.hospitalmedicine.org/ResourceRoomRedesign/RR_VTE/PDFs/VTEPreventionGuidev3.3.pdf)
- <sup>11</sup> White Paper. Deep-vein thrombosis: Advancing awareness to protect patient lives. 2003. [http://www.apha.org/NR/rdonlyres/A209F84A-7C0E-4761-9ECF-61D22E1E11F7/0/DVT\\_White\\_Paper.pdf](http://www.apha.org/NR/rdonlyres/A209F84A-7C0E-4761-9ECF-61D22E1E11F7/0/DVT_White_Paper.pdf)
- <sup>12</sup> Cohen AT, Davidson BL, Gallus AS, et al. Efficacy and safety of fondaparinux for the prevention of venous thromboembolism in older acute medical patients: randomised placebo controlled trial. BMJ 2006;332:325-329.
- <sup>13</sup> Samama MM, Cohen AT, Darmon JY, et al. A comparison of enoxaparin with placebo for the prevention of venous thromboembolism in acutely ill medical patients. N Engl J Med 1999;341:793-800.
- <sup>14</sup> Leizorovicz A, Cohen AT, Turpie AGG, Olsson CG, Vaitkus PT, Goldhaber SZ. Randomized placebo-controlled trial of dalteparin for the prevention of venous thromboembolism in acutely ill medical patients. Circulation 2004;110:874-879.
- <sup>15</sup> Kleber F-X, Witt C, Vogel G, Koppenhagen K, Schomaker U, Flosbach CW. Randomized comparison of enoxaparin with unfractionated heparin for the prevention of venous thromboembolism in medical patients with heart failure or severe respiratory disease. Am Heart J 2003;145:614-621.
- <sup>16</sup> Guyatt, et al, Executive Summary: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. Chest February 2012: 141:2 suppl 7S-47S.
- <sup>17</sup> Colwell CW Jr, Spiro TE, Trowbridge AA, et al. Use of enoxaparin, a low-molecular-weight heparin, and unfractionated heparin for the prevention of deep venous thrombosis after elective hip replacement: a clinical trial comparing efficacy and safety. J Bone Joint Surg Am 1994;76:3-14. [Erratum, J Bone Joint Surg Am 1994;76:4741.]
- <sup>18</sup> Brookenthal KR, Freedman KB, Lotke PA, Fitzgerald RH, Lonner JH. A meta-analysis of thromboembolic prophylaxis in total knee arthroplasty. J Arthroplasty 2001;16:293-300.
- <sup>19</sup> Geerts WH, Jay RM, Code KI, et al. A comparison of low-dose heparin with low-molecular-weight heparin as prophylaxis against venous thromboembolism after major trauma. N Engl J Med 1996;335:701-707.
- <sup>20</sup> Green D, Lee MY, Lim AC, et al. Prevention of thromboembolism after spinal cord injury using low-molecular-weight heparin. Ann Intern Med 1990;113:571-574.
- <sup>21</sup> American Academy of Orthopaedic Surgeons clinical practice guideline, Preventing Venous Thromboembolic Disease in Patients Undergoing Elective Hip and Knee Arthroplasty. September, 24, 2011. [http://www.aaos.org/research/guidelines/VTE/VTE\\_summary\\_of\\_recs.pdf](http://www.aaos.org/research/guidelines/VTE/VTE_summary_of_recs.pdf) (Accessed March 16, 2102)
- <sup>22</sup> Hull R, Schellong S, Tapson V, et al. Extended-duration venous thromboembolism prophylaxis in acutely ill medical patients

with recent reduced mobility: the EXCLAIM study. In: Program and abstracts of the XXI Congress of the International Society of Thrombosis and Haemostasis, Geneva, July 6-12, 2007:O-S-001.

<sup>23</sup> Cynthia P, Hughes C, Baumhover L. Impact of a nurse-driven mobility protocol on functional decline in hospitalized older adults. *J Nsg Care Quality*. 2009;24(4):325-333.

<sup>24</sup> Timmerman R. A mobility protocol for critically ill adults. *Dimensions Crit Care Nsg*. 2007;26(5):175-179.

<sup>25</sup> American Academy of Orthopaedic Surgeons (AAOS). American Academy of Orthopaedic Surgeons clinical guideline on prevention of symptomatic pulmonary embolism in patients undergoing total hip or knee arthroplasty. Rosemont (IL): American Academy of Orthopaedic Surgeons (AAOS); 2007. 63 p.

<sup>26</sup> [AHRQ Prevention of VTE Following Hip and Knee Reconstruction Synthesis of Guidelines](#)

<sup>27</sup> Timmerman, Rosemary, A Mobility Protocol for Critically Ill Adults, *Dimensions of Critical Care Nursing* Vol. 26 / No. 5, September/October 2007: 175-179

[http://www0.sun.ac.za/Physiotherapy\\_ICU\\_algorithm/Documentation/Rehabilitation/References/Timmerman\\_2007.pdf](http://www0.sun.ac.za/Physiotherapy_ICU_algorithm/Documentation/Rehabilitation/References/Timmerman_2007.pdf)

<sup>28</sup> Hsaio et al, Nurses' knowledge of high-alert medications: instrument development and validation, *Journal of Advanced Nursing* 66(1), 177-190

<sup>29</sup> Lu, M.-C. et al, Nurses' knowledge of high-alert medications, A randomized controlled trial, *Nurse Educ. Today* (2011)

<sup>30</sup> Qaseem et al, Venous Thromboembolism Prophylaxis in Hospitalized Patients: A Clinical Practice Guideline From the American College of Physicians, *Annals Internal Medicine* 155 (9):625-633 1 November 2011