When quality improvement with clinical decision support becomes iatrogenesis

Introduction

Venous thromboembolism prophylaxis has gained much attention from health-care systems, including a variety of quality improvement initiatives. Electronic health records and computerized physician order entry improve implementation of and compliance with clinical venous thromboembolism guidelines. Although computers have made the workflow easier, this article describes a case where blind obedience to computerized decision algorithms resulted in harm, although unintentionally, and discusses solutions for improvement.

Discussion

The estimated prevalence of venous thromboembolism in medical inpatients ranges from 10–20% and as high as 40–80% in surgical inpatients, contributing substantially to overall morbidity and mortality (Geerts et al, 2008). As pulmonary embolism is the most preventable cause of in-hospital death, strategies for risk assessment and prevention are justified and pervasive.

In 2008, the Center for Medicare & Medicaid Services identified venous thromboembolism as a preventable hospital-acquired condition resulting in reimbursement implications secondary to lack of appropriate venous thromboembolism prevention in patients undergoing hip or knee replacements. Likewise, The Joint Commission identified venous thromboembolism prevention as a core measure of in-hospital care quality

Figure 1. Calf haematoma noted on point-of-care bedside ultrasound.

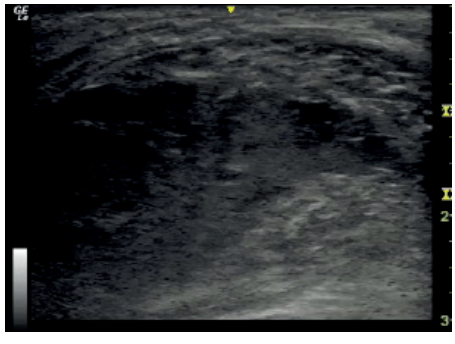
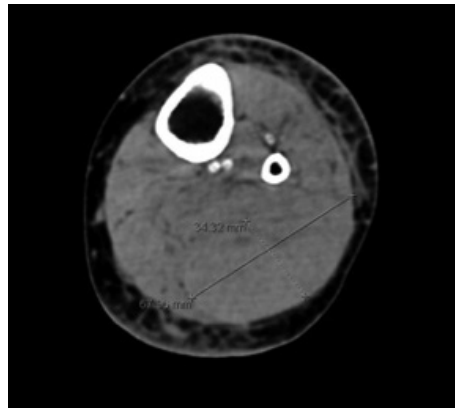


Figure 2. Large calf haematoma noted on computed tomography of lower extremity.



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CASE REPORT

A 62-year-old woman with recurrent venous thromboembolism, including recent pulmonary embolism, presented to the emergency room with back pain. Medical history included treated colon cancer, lumbar degenerative joint disease, hypertension and renal transplantation. Medications included mycophenolate, prednisone, tacrolimus, nifedipine and warfarin. Physical exam was unremarkable except for mild left paraspinal tenderness. She was admitted for analgesia and physical therapy.

One week previously, her international normalized ratio had been 3.3, and it was 6.8 on admission. Her platelet count and haemoglobin level were normal. She had no complaints of bleeding. A passive strategy for correcting the international normalized ratio by withholding warfarin was used.

Upon arrival to the ward, the admitting team used the electronic health record to order an admission careset via computerized physician order entry. Embedded within the order set was computerized clinical decision support for venous thromboembolism risk assessment. The patient was assigned as high risk for venous thromboembolism. Options for prophylaxis, including pharmacological, mechanical and none, were provided via an alert checklist. However, as this patient was designated as 'high-risk' at least one option for prophylaxis needed to be selected to prevent a system-generated alert being activated that blocked further orders until a method of prophylaxis was selected.

As the patient had a supratherapeutic international normalized ratio, a mechanical approach with intermittent pneumatic compression was selected to activate the venous thromboembolism prophylaxis portion of the admission order. Shortly after application of intermittent pneumatic compression, the patient reported severe left lower extremity pain, centred over the calf. She was otherwise ready for discharge, but over the next 24 hours the leg became progressively more swollen and painful with diminishing pulses. Bedside ultrasound (*Figure 1*) revealed a large left calf fluid collection suspicious for haematoma, confirmed with a computed tomography scan of the leg (*Figure 2*). International normalized ratio was 4.36 and her haemoglobin level dropped to 101 g/litre from 140 g/litre the previous day. Compartment syndrome was diagnosed, and the patient underwent an emergent posterior compartment fasciotomy and haematoma evacuation.

The patient required multiple transfusions of fresh frozen plasma and packed red blood cells to correct her coagulopathy and anaemia. Intermittent pneumatic compression was discontinued on the day of surgery and never re-ordered. Anticoagulation was cautiously resumed 7 days post-surgery. She ultimately remained in the hospital for 9 days. There have been no bleeding complications 6 months post-discharge with a therapeutic international normalized ratio; the patient has no residual complications from the fasciotomy.

and accreditation. In the context of this oversight, combined with rapid deployment of computerized clinical decision support for various conditions, in the USA a nationwide quality improvement and patient safety movement has focused on in-hospital venous thromboembolism prevention (Agency for Healthcare Research and Quality, 2016).

Computerized clinical decision support offers 'systematic, standardized application of health-related knowledge that enables providers to make informed clinical decisions at the point of care' with the intent of improving quality of care and decreasing cost (Osheroff et al, 2007). Widespread implementation has decreased venous thromboembolism rates and improved adherence to The Joint Commission quality measures. In a meta-analysis of surgical patients, venous thromboembolism prophylaxis orders increased significantly using computerized clinical decision support (odds ratio 2.35, 95% confidence interval 1.78–3.10, $P<0.001$) accounting for a decrease in rates of venous thromboembolism (relative risk 0.78, 95% confidence interval 0.72–0.85, $P<0.001$) (Borab et al, 2017). Other studies validated these findings for both medical and surgical patients, demonstrating that computerized clinical decision support can bridge the gap between guideline recommendations and clinical practice.

Computerized clinical decision support increases compliance with quality measures including medication errors and venous thromboembolism prophylaxis (Lau and Haut, 2014; Jia et al, 2016). However, despite compliance rates nearing 100%, prescription of appropriate prophylaxis still ranges from 34% to 78% (Quarishi et al, 2001). The reasons for this are multifactorial, including clinician knowledge and design of robust computerized clinical decision support algorithms.

Using computerized clinical decision support is not without limitations, and can have unintended consequences (Zhang et al, 2004; Koppel et al, 2005; Ash et al, 2007a). Ash et al (2007b) described two major patterns of unintended consequences of computerized clinical decision support related to content and presentation. The former focuses on inappropriate algorithmic content. In the current case, an inappropriate prophylaxis choice was allowed, despite an appropriate risk assessment. Unintended consequences also arise from the way alerts are presented to the user. In the current case, alert fatigue and system rigidity to proceed with further computerized physician order entry were likely contributing factors to an adverse event.

Predictive algorithm-based selection will invariably exclude patients who do not 'follow the rules' and may diminish clinicians' capacity for independent judgements. Such overreliance on technology for clinical decision making, combined with alert fatigue and annoyance, likely results in hurried decisions in order to circumvent the barrage of pop-up reminders. Computerized clinical decision support should not be a static framework. Periodic assessment and feedback loops are necessary to ensure the procedure remains robust (Eberhardt et al, 2012).

In the current case, a provider satisfied the prophylaxis option on the venous thromboembolism careset without regard to the patient's supratherapeutic international normalized ratio. The system does not allow concurrent visualization of the risk assessment tool and relevant patient data, notably laboratory values. Changes to reduce opportunities for a similar occurrence may incorporate inclusion of relevant clinical information (i.e. international normalized ratio) within the computerized clinical decision support framework to streamline appropriate venous thromboembolism prevention. While this is the first reported case of an intermittent pneumatic compression device traumatically resulting in a haematoma, better education and implementation of computerized clinical decision support could have avoided such a near-catastrophic event.

Conclusions

Given the high prevalence of in-hospital venous thromboembolism, prevention strategies should be ubiquitous. Using computerized clinical decision support has advantages, including provider workflow and guideline adherence to quality measures. However, clinicians must understand its limitations and systems need to be refined in response to adverse effects. Careful consideration and education of stakeholders can ensure successful implementation. Similar to other technologies, computerized clinical decision support is only as good as the providers and health systems using it. **BJHM**

LEARNING POINTS

- Electronic order sets can have unintended consequences, such as facilitating the choice of contraindicated interventions.
- When electronic decision support aids are constructed, care must be taken to incorporate barriers against iatrogenic complications, even seemingly innocuous interventions such as pneumatic compression devices.
- Periodic reassessment and feedback loops are important to identify gaps in support systems framework.

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