Routine coagulation testing in intensive care

Steven Musca, Shilpa Desai, Brigit Roberts, Timothy Paterson
and Matthew Anstey

There is increasing awareness of overservicing with pathology tests in the community[1] and in hospitals[2], and there has been global exposure of this issue via the Choosing Wisely campaigns.[3] Unnecessary investigations have several unintended consequences: potential false positives and follow-on treatments, patient harm, laboratory congestion and financial cost. These must be balanced against the benefits of up-to-date results and the risks associated with delayed testing.

Patients in the intensive care unit receive multiple daily investigations, including laboratory tests and chest x-rays. Routine ordering of daily chest x-rays is now considered to be a low-yield and unnecessary practice,[4,5] but there is limited literature relating to reducing pathology tests ordered in the ICU. A small study in an ICU in the United Kingdom found that over 40% of the cost of inappropriate blood tests was attributable to coagulation screens.[6] In 2015, a Canadian group used a multipronged approach to successfully reduce routine ordering of full blood counts (FBCs) and electrolyte panel tests in a 15-bed ICU, resulting in a modest saving over a 1-year period.[7]

In response to the lack of research in the Australian setting, we conducted a quality improvement study aimed at reducing the unnecessary ordering of coagulation profile tests in the ICU.

Methods

We defined a coagulation profile as a set of tests that included prothrombin time, international normalised ratio (INR), activated partial thromboplastin time (aPTT) and fibrinogen level. A coagulation test refers to any one of the coagulation profile tests, aPTT or INR.

We performed our study at a 23-bed, mixed tertiary ICU in Western Australia. The ICU treats transplantation, haematological, neurosurgical and cardiothoracic surgical patients, but treats limited numbers of major trauma patients. We did not include patients in the high dependency unit. We studied blood tests ordered for 100 consecutive patients (644 bed-days) before our intervention and 153 consecutive patients (687 bed-days) after our intervention. We included all patients admitted to the ICU during the two study periods (11 May to 10 July 2015 and 18 August to 22 September 2015) and recorded FBCs; urea, electrolytes and creatinine (UEC) tests; liver function tests (LFTs); coagulation profiles; INRs; and aPTTs. Pathology tests

ABSTRACT

Objective: To test a simple clinical guideline to reduce unnecessary routine testing of coagulation status.

Design, setting and participants: A prospective, unblinded, observational study of coagulation testing frequency before and after introduction of a simple clinical guideline. We included 253 patients admitted to a tertiary intensive care unit: 100 patients consecutively enrolled before our intervention (May – July 2015) and 153 patients consecutively enrolled after our intervention (August – September 2015).

Intervention: We introduced a clinical guideline and educational program in the ICU from 18 August 2015.

Main outcome measures: The number of coagulation tests performed per patient bed-day, and the associated pathology costs.

Results: Over the 3-month sample period, 999 coagulation profiles were performed for 253 patients: 720 (72%) in 100 patients before, and 279 (28%) in 153 patients after our intervention. The testing frequency fell from 1.12 to 0.41 per patient bed-day ($P < 0.001$). A total of 463 pre-intervention coagulation profiles (64%) were classified as unnecessary, and the cost of all coagulation tests fell by 60.5% per bed-day after the intervention.

Conclusion: A simple clinical guideline and educational package reduced unnecessary coagulation tests and costs in a tertiary referral ICU.

are almost exclusively ordered via a computerised physician order entry (CPOE) system by doctors, mainly junior medical staff. Each doctor has a personalised login to track orders. On rare occasions, orders are added manually on to printed forms by bedside nurses without prior authorisation.

At our hospital, coagulation profiles were more expensive, at $25.07, than FBCs ($15.25) and UEC tests ($15.82), and our ordering rates were similar for all three tests. Consequently, coagulation testing was selected for this study because of its higher cost, and the need for additional blood to be drawn.

We obtained approval for our study as a quality improvement activity from the Human Research Ethics Committee at our institution, with a waiver of consent for patients and medical staff.

Figure 1. Study categories for coagulation profiles

Unnecessary coagulation profile	INR < 1.4, aPTT < 43, AND coagulation profile reordered within 72 hours
Inappropriate coagulation profile	Only INR > 1.3 OR aPTT > 42, AND coagulation profile ordered instead of only INR or aPTT

INR = international normalised ratio. aPTT = activated partial thromboplastin time (seconds).

Intervention

We classified coagulation profiles ordered in the initial audit as in Figure 1 to estimate overservicing, and designed a clinical guideline and education package that included face-to-face educational, electronic and poster-based elements.

From 18 August 2015, a poster was placed above computers that displayed prices for the coagulation tests, estimated percentages of unnecessary or inappropriate tests and a guideline for requesting coagulation tests (Figure 2). We believed it was reasonable for a baseline coagulation profile test to be ordered on admission to the ICU unless it was clearly not relevant to the patient's presenting condition or it had already been done that day. Residents were educated on their orientation day by an intensivist, and the electronic system for ordering test sets routinely and on admission had the coagulation profile option removed from the default orders. Halfway through the second audit, an email was sent to all doctors in the ICU to update them on the progress of the study, and to celebrate the two doctors with the best coagulation test ordering practice. The two doctors with the worst ordering practice were emailed privately. These doctors were identified using a manual CPOE system review.

Figure 2. Guideline for ordering coagulation tests

Trigger	Action
On ICU admission	→ Order screening coagulation profile if not done that day
Arising during ICU stay:	
• Significant bleeding	→ Order coagulation profile as required

• Before significant procedure:
  - New thrombocytopenia <50
  - Liver failure
  - DIC
	→ Order coagulation profile once and then daily if abnormal*

• Warfarin therapy Isolated high INR (>1.3)	→ INR only, daily or less when patient improving
• Heparin therapy Isolated high aPTT (>42)	→ aPTT only, as per heparin protocol, or daily or less if patient improving
• Coagulation profile abnormal* but none of the above	→ Consider ordering coagulation profile second daily or less if patient improving

ICU = intensive care unit. DIC = disseminated intravascular coagulation. INR = international normalised ratio. aPTT = activated partial thromboplastin time. * INR > 1.3; aPTT > 42 s; fibrinogen excluded.

Outcomes

Primary outcomes were the number of coagulation profiles, all coagulation tests (including aPTT and INR) and the costs associated with these. We also measured other ordering patterns for blood tests in the ICU and the blood volumes taken for coagulation tests. Doctors were asked to report any observed adverse events associated with a reduction in coagulation testing (eg, missed coagulation tests and subsequent undetected bleeding or delay in transfer to theatre).

Statistical analyses

We performed descriptive statistical analyses, characterising the raw data as means and SDs, or medians and interquartile ranges (IQRs). We calculated the number of blood tests per day for each patient's ICU stay, and blood tests per bed-day as the total number of tests per total number of bed-days. We compared groups using independent sample *t* tests, and performed multivariate logistic regression analysis adjusted according to the following basic characteristics: ICU length of stay; type of admission; Acute Physiology and Chronic Health Evaluation (APACHE) II score; and age. A two-tailed $P < 0.05$ was considered significant. We performed statistical analysis using Stata, version 12 (StataCorp).

Results

We included a total of 253 patients over a combined sample period of 3 months, with 1 month between Audit 1 and Audit 2. The demographic data of the two audit groups are shown in Table 1. A summary of tests, totals and weighted per patient, is shown in Table 2.

Before our intervention, of the 720 coagulation profile tests ordered in Audit 1, 296 (41.1%) were considered unnecessary and 167 (23.2%) were considered inappropriate, based on the definitions in Figure 1. We therefore anticipated that a maximal reduction of about 64% in coagulation profile tests could be achieved.

The reduction achieved in ordering of coagulation profiles was 63.68% on an overall per bed-day basis, with an expected small rise in aPTT and INR tests ordered as the

previously inappropriately ordered coagulation profiles were replaced by these less costly tests (see Figure 3). In comparison, there was a 14.97% reduction per bed-day in the bundle of FBC, UEC and LFT tests. This reduced the overall cost for coagulation testing from $28.47 to $11.24 per bed-day (a reduction of 60.5%). The difference in rates of testing remained significant between the two groups after logistic regression analysis to control for ICU length of stay, type of admission, APACHE II score and age ($P = 0.0001$).

After the feedback email sent about halfway through the second audit period, the total coagulation tests were reduced by an average of a further 0.066 per day of each ICU stay, which was not significant ($P = 0.5458$). The volume of blood taken for coagulation testing (in a 2.7 mL citrate tube) dropped by 1.79 mL/bed-day between the audits.

There were no reported adverse events relating to bleeding or morbidity from a missed coagulation test.

Discussion

Through our simple education and electronic ordering modification package, we were able to reduce coagulation profile testing by 63.68% per bed-day with no observed complications. The overall cost reduction for all coagulation tests was 60.52%. For our unit, this equated to a saving of $98 349 per year (calculated based on the 2014 bed-day total of 5708).

This is a relatively small proportion of daily ICU costs (an average ICU bed cost $4028 per day in New South Wales in 2009–10),[8] but it represents only one of many potentially overordered investigations. Using admissions figures from the Australian and New Zealand Intensive Care Society (ANZICS) Adult Patient Database for 2013–14,[9] we estimate the potential cost reduction to be $3 854 730 per year (based on adult ICU admissions of 124 290 and an average ICU length of stay of 1.8 days). This may be an underestimation, because 24.3% of ICUs do not contribute to the ANZICS database and there are higher charges for pathology testing at private hospitals.

There is growing awareness that pathology tests do not always provide useful information and that a reduction of routine and repeat testing is a strong opportunity for cost savings and fewer false positive test results. For example, one of the Choosing Wisely campaign recommendations of the Critical Care Societies Collaborative in the United States is "Don't order diagnostic tests at regular intervals (such as every day), but rather in response to specific clinical questions."[10]

Reasons for overordering pathology tests include fear of missing a diagnosis, fear of litigation, "just in case",

lack of understanding of pathophysiological concepts, default order sets, and lack of clear ordering guidelines. Previous research suggests that health professionals often have limited understanding of the costs of investigations, regardless of their experience.[11]

Table 1. Comparison of patient demographics, with two-tailed *P* values

Parameter	Audit 1	Audit 2	P*
No. of patients/bed-days	100/644	153/687	–
Median time in ICU, days (IQR)	4 (3–7)	3 (2–5)	0.013
Mean age, years (SD)	57.15 (15.62)	55.84 (17.16)	0.532
Median APACHE II score (IQR)	17 (13–23)	15 (11–20)	0.035
Admission type, %			
Emergency/elective	78%/22%	68%/32%	0.049
Surgical/medical	44%/56%	55%/45%	0.091
Top primary diagnoses, n			
CABG	11	23	–
ICH	9	12	–
Sepsis	8	11	–
Respiratory failure	7	15	–
Cardiothoracic surgery, n	17	33	–
Neurosurgery, n	12	18	–

ICU = intensive care unit. IQR = interquartile range. APACHE = Acute Physiology and Chronic Health Evaluation. CABG = coronary artery bypass grafting. ICH = intracranial haemorrhage (including subarachnoid, subdural and intraparenchymal haemorrhage). * Significance set at $P < 0.05$.
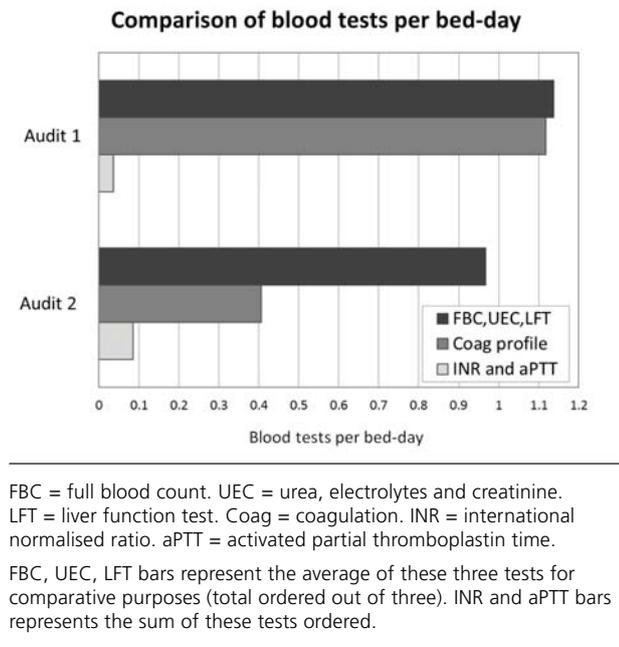
Table 2. Summary of results, with tests weighted per patient

Parameter	Audit 1	Audit 2	Difference (95% CI)	P*
Bed-days	644	687	–	–
Coag profile	720	279	–	–
Coag profile/aPTT/INR	741	338	–	–
FBC/UEC/LFT	2197	1993	–	–
Patients with no coag tests in ICU	5	21	–	–
Average per day per patient				
Coag profile	1.068	0.539	0.529 (0.402–0.657)	< 0.001
Coag profile/aPTT/INR	1.088	0.651	0.437 (0.293–0.580)	< 0.001
FBC/UEC/LFT	5.367	4.682	0.685 (0.288–1.082)	0.003

Coag = coagulation. aPTT = activated partial thromboplastin time. INR = international normalised ratio. FBC = full blood count. UEC = urea, electrolytes and creatinine. LFT = liver function test. ICU = intensive care unit. * Significance set at $P < 0.05$.

Figure 3. Comparison of blood tests before and after intervention

Comparison of blood tests per bed-day

FBC = full blood count. UEC = urea, electrolytes and creatinine. LFT = liver function test. Coag = coagulation. INR = international normalised ratio. aPTT = activated partial thromboplastin time.

FBC, UEC, LFT bars represent the average of these three tests for comparative purposes (total ordered out of three). INR and aPTT bars represents the sum of these tests ordered.

As part of our quality improvement process, we consulted our pathology department to better understand how our investigations were billed. In our ICU, and in many other Australian ICUs, test ordering is usually performed by junior staff. There was an ICU order set and an orientation and guideline book for new medical staff, but there were no explicit instructions relating to the frequency of ordering tests, and the use of routine ICU ordering sets could inadvertently increase the ordering of pathology tests. The rise in the number of patients for whom no coagulation tests were performed during their ICU stay (from five to 21 [Table 2]) after our intervention may have been because of more individualised ordering as a result of staff education.

We present a successful systematic approach to quality improvement in the ordering of medical investigations that we believe can be replicated in other ICUs and hospital departments. A program for reduction of coagulation tests has been rolled out in the cardiology and emergency departments at our hospital, and other target tests are currently being assessed. We believe this could apply to a variety of other routine pathology and radiological tests, such as blood gases, LFTs and chest x-rays.

Staff who want to implement this approach in their hospital should start by examining the billing protocols of their pathology provider, the volume of tests ordered and current workflow practices. Changes could include:

- altering the defaults and prompts in the CPOE (at our hospital, we now have warnings displayed for repeat tests[12] and price displays)[13]

- leadership from the consultant group to promote the new practices

- engaging the nursing staff (who are an important resource for junior doctors)

- educating each new cohort of medical staff.

In our study, a feedback email did not seem to change practice further, but monitoring and updates on performance are likely be effective in maintaining ongoing compliance and interest.

Limitations

There were several limitations to our study. First, it was a single-centre study with no comparative data from other sites, but the results are comparable to those achieved in other countries.[6,7] Second, it may be that our prospective study created an inadvertent comparison of two groups of junior staff, or two separate patient populations. Patients in the second audit group had a lower median APACHE II score and a shorter median ICU length of stay, but the logistic regression model created to control for these factors showed that the results remained significant. Further, our hospital does not have a large volume of patients admitted for major trauma, and we did not include the use of rotational thromboelastometry (which is not commonly used) in our study. In addition, other than asking staff to report adverse events, we did not search further for them, and may have underestimated any potential harms of reducing coagulation tests. Finally, our results may reflect the Hawthorne effect (in which subjects alter their behaviour due to their awareness of being observed) rather than the components of our audit.[14] However, coagulation profiles were reduced dramatically more than the other pathology tests measured.

Conclusion

We tested a simple clinical guideline and educational package to guide clinicians in ordering routine coagulation tests in a tertiary referral ICU. We showed a significant reduction in unnecessary tests and patient costs. This methodology may have application to other tests and other clinical services.

Competing interests

None declared.

Author details

Steven Musca, Registrar[1]

Shilpa Desai, Resident[1]

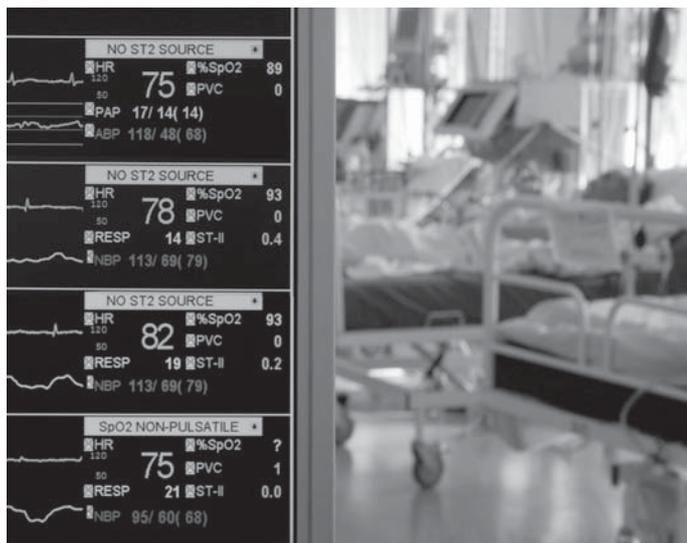Brigit Roberts, Research Co-ordinator[1]

Timothy Paterson, Intensivist[1]

Matthew Anstey, Intensivist[1] and Research Adjunct[2]

1 Intensive Care Unit, Sir Charles Gairdner Hospital, Perth, WA, Australia.

2 School of Public Health, Curtin University, Perth, WA, Australia.

Correspondence: steven.musca@gmail.com

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