Written Guidelines for Laboratory Testing in Intensive Care - Still Effective After 3 Years

S. M. MEHARI, J. H. HAVILL
Intensive Care Unit, Waikato Hospital, Hamilton, NEW ZEALAND

ABSTRACT

Objective: *The aim of the study was to examine the effect of time on written guidelines for laboratory testing in an intensive care unit by comparing the numbers of tests performed with those performed three years previously.*

Methods: *In 1995, guidelines were developed for blood test ordering in the Waikato Hospital intensive care unit, which when implemented resulted in a decrease in all blood tests performed by 16.6% in a group of general intensive care patients and by 25.9% in a group of post cardiac surgery patients. We repeated this study on similar groups of patients to see if the guidelines were still effective. Data on age, APACHE II score, diagnosis, and ventilation time were collected. Comparisons were made of tests performed per patient and per ventilation time in hours.*

Results: *In the general intensive care patient group, there was an increase of 2.1% tests performed per patient, but a decrease in tests performed per ventilation time of 5.6%. In the postoperative cardiac surgery patient group, the total number of tests performed per ventilation time decreased by 4%. The arterial blood gases performed per patient increased by 10.7% in the general intensive care patient group, and decreased by 14.3% in the postoperative cardiac surgery patient group. However, when the number of arterial blood gases performed per ventilation time was compared with the 1995 study, there was no difference in the general intensive care patient group, while there was a reduction by 8.3% in the postoperative cardiac surgery patient group.*

Conclusions: *Three years after the implementation of guidelines for laboratory testing in an intensive care unit, there was no return to the level of testing recorded before the guidelines were introduced. The number of tests per ventilation time decreased by 4% in postoperative cardiac surgery patients and decreased by 5.6% in the general intensive care patients. In our study written guidelines remained effective three years after their introduction.* (**Critical Care and Resuscitation 2001; 3: 158-162**)

Key words: Guidelines, protocols, intensive care, cost

In 1995 we developed guidelines for laboratory testing in patients within the Waikato hospital intensive care unit (ICU), which were associated with a decrease in testing varying between 16% and 25%.[1] This resulted in potential savings of $80,000 (NZ) per year.

The question was then asked as to whether this result would last, especially as all junior medical staff and many nursing staff have changed. Some doubt whether guidelines achieve anything at all and have suggested that even if they do, the effect will not persist and staff will soon move back to their old habits. Others give reasons for not even bothering to write guidelines in the first place.[2]

We have previously recorded in an earlier study that temporary benefit is obtained in prevention of unnecessary routine blood tests.[1] We decided to repeat this study on similar groups of patients to see if the guidelines were still effective.

METHOD

The study was carried out using the same criteria in the same intensive care setting as the previous study.[1] Only mechanically ventilated patients with an intra-arterial indwelling catheter were selected. Blood tests were performed on 50 consecutive general intensive

Correspondence to: S Mehari, Intensive Care Unit, Waikato Hospital, Private Bag 3200, Hamilton, New Zealand

care patients and 50 consecutive post-cardiac surgery patients who fulfilled the criteria.

Data were collected retrospectively from our clinical data charts and up to the sixth day of ventilation, or when ventilation stopped, which ever came first. The blood tests targeted were the complete blood count (CBC), coagulation screen (INR and APTT), urea, creatinine, sodium, potassium and glucose (U + E), calcium, magnesium, phosphate and arterial blood gases (ABG's). Arterial blood gas tests are usually ordered at the discretion of the nurse whereas other tests are usually ordered by the junior medical staff. Data concerning the age, APACHE II score, length of time on ventilation and diagnosis for each patient were also obtained. The same written guidelines (Table 1, 2 and 3) used for the earlier study were placed on every patient's chart board for staff reference.

Table 1. Intensive care unit guidelines for ordering blood tests

CBC		**COAGULATION SCREEN**	
Indications	*Frequency*	*Indications*	*Frequency*
Patient with normal baseline results	Daily haemoglobin, platelets, WBC	Normal baseline results and stable patients	Only on Doctor's request
Unstable DIC Patients with bleeding, oozing wounds. Platelet monitoring needed, e g. thrombocytopenia	12-hourly	Following blood product transfusion. Where given to correct coagulation abnormality. Patients relatively unstable and septic	Daily
Afebrile and patient with normal previous WCC	Differential WBC not required	On heparin infusion	APTT as per order sheet
Patients with pyrexia or elevated WCC	Daily differential WBC	On subcutaneous heparin	Daily APTT
Extra CBC	On Doctor's request	On warfarin	Daily INR
U + E **Glucose, magnesium (Mg^{++}), phosphate (PO_4)**		**LFT's**	
Indications	*Frequency*	*Indications*	*Frequency*
U + E: Stable patients and patients with normal baseline results	Daily or less for long-term patients	Normal baseline results and stable patients	48-hourly
U + E: Patients with cerebral injury and where Na levels are important (e.g. hyponatraemia)	6 to 8-hourly	Septic and critically ill	48-hourly
U + E: Renal failure and having renal resuscitation	12-hourly	Extra LFT's	On Doctor's request
U + E: Diabetic coma	2 hr initially then as ordered		
U + E: To check accuracy of ABG machine if K levels error suspected	As required		
U + E	On Doctor's request		
Ca^{++}, Mg^{++}, PO_4: Patients having treatment with same	12-hourly		
K^+: Patients on cardiac protocol	Follow the protocol		
Glucose: Unstable with abnormal and difficulty in controlling glucose levels	4-hourly laboratory glucose		
Glucose: On unstable patients with normal B.M	8-hourly		
Glucose: For new diabetics	2-hourly initially		

CBC = Complete blood count, WCC = White cell count, LFT's = liver function tests, U + E = plasma Na^+, K^+, urea, creatinine and corrected calcium concentrations, Coagulation screen = APTT and INR

Table 2. Guidelines for ordering arterial blood gases

Indications	*Frequency*
New patient where relevant Returning from theatre, CT scan Re-intubated	As soon as feasible
Patient with respiratory rate > 30, low SaO_2, low MAP Head injury with sudden increase in ICP and pupil size	Immediately
Change in: • ventilatory mode • PEEP by 3-5 cm H_2O • inverse I:E ratio	Within 30 minutes
If inspiratory O_2 requirement is $\geq$ 60% and ABG results and oximetry SaO2 are within specified limits	4-hourly
FIO2 between 45 - 55% and ABG and oximetry SaO2 within specified limits	8-hourly
Following extubation: • On inspired O_2 through face mask at 8 L/min, if SaO_2 98% or greater for 10 minutes, reduce to 6 L/min • On inspired O_2 through face mask at 6 L/min if $SaO_2 \geq$ 97% for 10 minutes, reduce to 6 L/min, reduce to 4 L/min • On inspired O_2 at 4 L/min if SaO_2 between 95 - 97% continue on 4 L/min	After one hour from time of extubation
Extra ABG's	On special request from Doctor
When used for K+ levels and if cardiac protocol in action	Follow cardiac protocol as per U + E guideline

All patients must have pulse oximetry monitoring

Table 3. Cardiac protocol for potassium replacement

If serum $K^+ < 4.0$ mmol/L	Give 20 mmol KCl in > 20 mL 5% dextrose over 20 minutes
If serum K^+ 4.0 - 4.5 mmol/L	Give 10 mmol KCl in > 20 mL 5% dextrose over 20 minutes
If serum K^+ 4.5 - 5.0 mmol/L	Give 10 mmol KCl in > 20 mL 5% dextrose over 20 minutes if urine output > 1 mL/kg/hr

Repeat K+ estimations 10 minutes after completion of above doses and give repeat dose if necessary. The aim is to keep the K^+ in the high normal range of 4.5 - 5.0 mmol. The minimum K^+ levels are done immediately, 2-hourly for 6 hours and then 4-hourly for the remainder of 24 hours.

During orientation, staff were routinely made aware of the laboratory test guidelines. Staff members were unaware of the study. Student's *t* test was used to compare data and a $p < 0.05$ was accepted as level of significance.

RESULTS

Information was obtained from 50 consecutive general intensive care and 50 postoperative cardiac surgery patients. Five patients from the general intensive care group were excluded, because they had not fulfilled the criteria. Four had intra-arterial lines but were spontaneously breathing, and one while ventilated, did not have an arterial line during the time of data collection.

Similarly, one patient from the postoperative cardiac surgery group was eliminated because he was spontaneously breathing although he had an arterial line. Therefore, the results were based on the information obtained on 45 consecutive general intensive care patients and 49 consecutive post cardiac surgery patients.

The mean APACHE II scores and the mean ages of the general intensive care and cardiac patients in the 1998 study group are compared to the 1995 groups in table 4. Compared with the 1995 study, the mean ages in the 1998 groups were greater by 2 - 4 years and the mean APACHE II scores were less by 1.5 - 3.6.

The admission diagnoses of the general intensive care and post-cardiac surgery patients are shown in tables 5 and 6 respectively. The diagnoses are similar, although there were more head injury, trauma and sepsis cases in the 1995 general intensive care patients compared with the 1998 group. In the post cardiac surgery patients there were no major differences between groups. The laboratory tests performed and the differences between the 1998 and 1995 study groups are shown in Table 7.

Table 4. Mean age and APACHE II scores

	General intensive care patients		Post-cardiac surgery patients	
	1995 n = 49	1998 n = 45	1995 n = 51	1998 n = 49
Mean age (years)	48.59 ± 24.48	52.95 ±23.9	59.4 ±12.59	64.21 ±10.36
APACHE II score	10.93 ± 6.93	10.1 ± 7.0	10.05 ± 3.7	9.15 ± 3.2

Table 5. Diagnoses of general intensive care patients

Diagnosis	1995 N = 49	1998 N = 45
Head injury	9	5
Trauma	2	6
Sepsis	9	4
Abdominal aortic aneurysm repair	6	6
Cardiac arrest	4	5
Cerebral bleed	2	0
Drug overdose	2	5
Gastrointestinal surgery	5	3
Postoperative complications, bleeding	4	0
Other: seizures, gastrointestinal bleed, burns	6	11

Table 6. Diagnoses of post cardiac surgery patients

Diagnosis	1995 n = 51	1998 n = 49
Coronary artery bypass graft	35	34
CABG + AVR/CABG + MVR	0	8
Valve repair only	13	7
ASD	1	0
Resection of subaortic stenosis	2	0

CABG = Coronary artery bypass graft, AVR = Aortic valve repair, MVR = Mitral valve repair, ASD = Atrial septal defect

Table 7. Comparison of laboratory tests

General intensive care patients

	1995 n = 49		1998 n = 45		
Test	Total tests	Tests per patient	Total tests	Tests per patient	Difference %
CBC	237	4.83	248	5.51	14.1
Coag	237	4.83	181	4.02	- 16.8
U+E & glucose	268	5.47	255	5.67	3.7
Ca^{++}	233	4.76	190	4.22	- 11.3
Mg^{++}	245	5.0	202	4.49	- 10.2
PO_4	218	4.45	196	4.36	- 3.4
ABG	966	19.71	982	21.82	10.7
Total	2404	49.06	2254	50.09	2.1
p					0.24

Post – cardiac surgery patients

	1995 n = 51		1998 n = 49		
Test	Total tests	Tests per patient	Total tests	Tests per patient	Difference %
CBC	128	2.51	127	2.59	3.2
Coag	131	2.57	124	2.53	- 1.6
U+E & glucose	122	2.39	122	2.49	4.2
Ca^{++}	116	2.27	102	2.08	- 8.4
Mg^{++}	111	2.18	119	2.42	11.0
PO_4	89	1.75	107	2.18	24.6
ABG	680	13.33	560	11.42	- 14.3
Total	1377	27.0	1261	25.73	- 4.7
p					0.94

CBC = complete blood count; Coag = activated partial thromboplastin time and International normalised ratio, U+E & Glu = urea, creatinine, sodium, potassium and glucose, ABG = arterial blood gas

During the 1998 study, the urea and glucose tests were routinely 'ticked' in the laboratory form when a doctor ordered U + E and therefore are not shown in the tables as separate tests.

There was no significant difference between the total tests performed per patient (including ABG's) in either the general intensive care patient group (p = 0.24) or the post cardiac surgery patient group (p = 0.94).

In Table 8 the study groups are compared in terms of the number of tests performed per ventilation hours and the length of time the patients received mechanical ventilation. This was done to exclude the variation of time on number of tests performed. Although 2.1% more laboratory tests per patient were performed in the 1998 general intensive care patients, the patients had an increase of 8.1% ventilation time, and had an average of 5.6% less tests performed per ventilation time.

The 1998 cardiac group had 4.7% less overall laboratory tests per patient and 4 % less tests per ventilation time. Time spent receiving mechanical ventilation was almost identical (0.9% difference).

If the number of ABGs per patient are taken separately without taking the length of ventilation time into consideration, there is an increase by 10.7% in the 1998 general intensive care group and a decrease by 14.3% in the cardiac patients. However, when the ABG's per ventilation time are examined, there is no difference in the general intensive care patients, and an 8.3% decrease in the cardiac patients.

Table 8. Number of tests per ventilation time in hours

	General intensive care patients			*Post-cardiac surgery patients*		
	1995 n = 49	1998 n = 45	Difference %	1995 n =51	1995 n = 49	Difference %
Total laboratory tests per patient	49.06	50.09	2.1	27.0	25.73	- 4.7
Mean ventilation time/patient	55.4	59.9	8.1	10.9	10.8	- 0.9
Total test per ventilation time	0.89	0.84	- 5.6	2.5	2.4	- 4.0
ABGs per patient	19.71	21.8	10.7	13.33	11.4	- 14.3
ABGs per vent time	0.4	0.4	0	1.2	1.1	- 8.3

ABGs = arterial blood gases.

DISCUSSION

A recent study by Flabouris et al,[2] using a survey with 56% response rate and including 47% of the Australian and New Zealand intensive care units, suggested that the presence or absence of written guidelines did not influence the frequency of the most commonly performed routine blood tests. However the number of other variables in this study allowed for considerable uncertainty.

Reduction in the frequency of testing attributed to the use of guidelines has been reported in several studies, including our own[1,3,4]. It is unclear however, that where reduction of testing occurs, whether this effect lasts. Civeta documented a reduction that was maintained 6 months after the introduction of their intervention.[5] Our study suggests that written guidelines, accessible to staff on a patient chart-board, and mentioned in orientation to new nursing and junior medical staff, may prevent an increase in the number of routinely performed blood tests even after 3 years. We believe the provision of guidelines has created a "culture of testing and standardisation" that has continued, often unconsciously. For example, new patients returning after major surgery generally get a standard set of tests done to establish a baseline. Apart from establishing the initial guidelines by mutual discussion and mention during orientation, there has not been a great emphasis on restricting testing. In fact there is probably room for improvement without effecting patient safety.

In the general intensive care patients, blood tests for magnesium have decreased by 10.4% while the increase in the post operative cardiac patient group was 11%. This increase can probably be attributed to a magnesium study, which was in progress at the time. A plasma magnesium level < 1.5 mmol/L was required before commencing the patient in the trial. Additional tests were repeated if the results showed high serum levels.

In conclusion, our findings demonstrate that there was no significant difference in the number of laboratory tests performed between the 1998 and 1995 studies, which were carried out while the guidelines were in place. There was no return to the levels of testing before guidelines were instituted. The laboratory tests (including ABG's) per ventilation time in both postoperative cardiac and general intensive care groups of patients decreased by 4% and 5.6%, respectively.

Our study suggests that written guidelines with ongoing orientation for staff on laboratory testing can remain effective three years after their implementation.

Acknowledgments

We are grateful to Dr Jamie Sleigh for his assistance with the statistical analysis, and to Dianne Takiari-Dawson for her secretarial support.

Received: 24 April 2001
Accepted: 28 July 2001

REFERENCES

1. Mehari SM, Havill JH, Montgomery C. A written guideline implementation can lead to reduction laboratory testing in an Intensive Care Unit. Anaesth Intensive Care 1997;25:33-37
2. Flabouris A, Bishop G, Williams L, Cunningham M. Survey routine blood test ordering for patients in Intensive Care. Anaesth Intensive Care 2000;28:562-565.
3. Inman KT, Sibbald WJ, Rutledge F, et al. Does implementing pulse oximetry in a critical care unit result in substantial arterial blood gas savings? Chest 1993;104:542-546.
4. Pilon CS, Leathley M, London R, et al. Practice guideline for arteria blood gas measurement in the intensive care unit decreases numbers and increases appropriateness of tests. Crit Care Med 1997:25:1308-1313.
5. Civeta JM. No heeadlines, just headways, Crit Care Med 1993;21:116-1418.