ORIGINAL ARTICLE

High value healthcare analysis of "triggers" in deteriorating patients

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Abstract

Objective: To review "triggers" for deteriorating patients who required intervention by a medical emergency response team (MET). In addition, to assess whether these "triggers" differed by medical or surgical governance of these patients. A secondary objective was to report laboratory investigations performed via the MET, with particular interest in tests duplicating haemoglobin (Hb) values and their degree of concordance within the context of low-cost, high value inpatient care.
Methods: This quality improvement initiative involved a prospective observational cohort of inpatients, who were attended to by the MET at Royal Perth Hospital in Perth, Western Australia over a 2-year period between 2020 and 2022.
Results: The mean number of MET calls for inpatients under surgical governance was slightly higher than for those patients under medical governance (1.34 vs. 1.25 calls respectively $p = .03$). Hypotension triggered a MET call in 184 (40.9%) surgical patients compared to 154 (28%) under medical governance ($p < .001$). Comparing haemoglobin values obtained from FBP and VBG, Lin's concordance correlation coefficient (CCC) was found to be 0.986, 95%CI: 0.983, 0.989. The Bland-Altman limits of agreement suggest that the haemoglobin value on a VBG ranges from 9.55 g/L higher than the FBP to 4.7 g/L lower than the FBP.
Conclusions: Significant differences in the frequency of triggers for patients under medical vs surgical governance highlight the need for proactive planning around hypotension management of patients under surgical governance. In addition, understanding the nuances between haemoglobin values obtained from FBP and VBG can help with value-based health care and efficiencies in patient care, since measuring haemoglobin values is one of the key components in hypotension management.

Key Words: High value healthcare, Haemoglobin, Medical emergency review, Tertiary hospital, Venous blood gas

1. Introduction

As the field of medicine expands with an increasing focus on patient safety, quality and efficiency, it is apparent that the value of investigations and treatment is an important factor in healthcare.[1,2] However, Berwick and Hackbarth famously estimated that approximately 30 percent of healthcare is a waste, categorised into fraud, administrative waste, pricing failures and "low-value" healthcare.[2] Like many western countries, Australia has focused on "low-value" care as a key area of opportunity to optimise change[1,3] while meeting the needs of the patient.

Most notably in recent years is the national "Choosing Wisely" campaign which has a focus on "creating momentum for clinicians to take individual and collective responsibility for selecting health practices of limited value."[3] Whilst there are many concepts to the definition of "low-value" health-

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care, this article will define "low-value" healthcare as "use of an intervention where evidence suggests it confers no or very little benefit on patients. . . or more broadly the added costs of the intervention do not provide proportional added benefits."[1,4]

One area of focus in optimizing "low-value" healthcare is "after-hours" inpatient care. Most Australian hospitals are staffed to provide a functional "in-hours period" of 08:00 to 16:00 hours Monday to Friday, which is similar in most countries internationally.[5,6] There is a well-known discrepancy in outcomes between patients managed in the "in-hours" and "after-hours" period, with an excess mortality noted with "after-hours" admissions.[5,7–9] The literature suggests that the reasons for this discrepancy are due to limited staffing, delays to escalation, lack of senior decision making and poor utilization of early warning systems.[5,7,9] In addition, review of this literature suggests that differences exist between patients requiring different care modalities, such as medical and surgical governance.

For the reasons aforementioned, patients may deteriorate and most hospitals have a "medical emergency response team" (MET) to manage these situations.[10–12] Under the pressure of time critical situations, the MET is required to assess the patients' condition, order investigations such as laboratory blood tests and determine appropriate interventions to achieve positive patient outcomes.[11] It is estimated that laboratory testing represents the largest volume of activity in these scenarios and is likely to influence the vast majority of decision-making outcomes.[13,14] Typically, multiple blood tests are ordered to ensure a broad profile is obtained. However, it is unclear which, if any of these tests represent "low-value" healthcare.

A key laboratory blood test often performed in such scenarios is measurement of the haemoglobin (Hb) level[13,14] as low haemoglobin is associated with poorer patient outcomes[11] including blood transfusion. However, there are multiple test modalities that can be used to measure the haemoglobin level, with varying costs. Apart from costs, these tests have different advantages and disadvantages. For example, in the case of Haemoglobin level, both a Full Blood Picture (FBP) and a Venous Blood Gas (VBG) can provide a haemoglobin value, although a VBG has a much faster processing time and provides a result within 15 minutes, however a FBP can provide more detail into the other constituents of the blood test (e.g. haematocrit level, platelet count, etc.) but can take up to 60 minutes. Discrepancies can arise when there are variations between test modalities on the same parameter outcome, for example a FBP and VBG can often provide a different Haemoglobin value taken from the same sample, which requires clinical judgement to interpret and make an appropriate patient-based decision.

The aim of this study was to describe the triggers that initiated the "after-hours" medical emergency team attendance and the laboratory blood tests requested in response in critically deteriorating in-patients in a tertiary public hospital. In addition, optimisation of haemoglobin blood tests requested was explored for potential contribution towards minimizing "low-value" care while maintaining timely and quality provision of healthcare. Ultimately, this review of practice aimed to inform a refinement in processes to rationalize certain blood tests ordered in an emergency response setting.

2. METHODS

2.1 Quality improvement initiative design and participants

This quality improvement initiative was conducted on a prospective observational cohort of inpatients who were attended to by the medical emergency response team (MET) at Royal Perth Hospital in Perth, Western Australia, over a 2-year period between 2020 and 2022. Royal Perth Hospital is a tertiary level hospital focusing on adult medicine.[5] Only patients who had a registered medical emergency response, signified by a hospital recording through the telecommunication system, were included. Repeat calls to the MET in the same admission were included.

2.2 Variables

Patient and MET call details were collected via paper forms with specified fields outlining the nature and location of the MET call, the trigger, and the outcome of the MET call.

Triggers resulting in attendance by the MET were recorded as due to cardiac arrest, change in respiratory rate, decreased oxygen saturations, change in heart rate outside parameters, change in blood pressure, change in conscious state and general concern about the patient not specified.

Blood tests requested were retrieved from an electronic record system. The tests were the Full Blood Picture (FBP), Urea, Electrolytes and Creatinine (UEC), Arterial Blood Gas (ABG), Venous Blood Gas (VBG).

FBP measures the haemoglobin level in the blood (normal range 115-160 g/L) as well as other key blood components such as white cell count and platelets, markers of infection and body clotting. ABG analyses the arterial oxygenated blood and is an alternative mode of obtaining a haemoglobin level, as well as arterial pH of the blood and lactate. VBG reports on the venous deoxygenated blood, and also provides the haemoglobin level, along with venous pH of the blood and lactate. UEC looks at the electrolyte levels in the blood and renal function.

All blood tests were processed through the same laboratory.

Patients were divided into two types of admission governance, medical and surgical. Medical governance included patients that were admitted under a consultant specialist with a medical qualification, which includes units such as general medicine and specialty medicine (e.g., Respiratory, cardiology etc.). Patients requiring psychiatric care with medical input were also classed as medical governance. Surgical governance included patients who had inpatient surgery in a surgical theatre and were admitted under a consultant specialist with a surgical qualification.

Other outcomes of interest were in-hospital mortality, 30-day mortality and intensive care unit admission.

2.3 Statistical analysis

Data were summarized as counts and proportions or mean and standard deviation (*SD*) and first to third quartile [Q1-Q3] as appropriate. The potential for multiple MET calls within an admission and multiple admissions per patient, required analysis methods to account for potential correlation between MET calls due to the hierarchical nesting. To this end, regression techniques were used to test for differences between medical and surgical groups. Mixed effects logistic regression was performed for binary variables and linear mixed models for continuous variables. Bootstrapping was employed to generate robust p-values if the validity of normality or homoscedasticity assumptions were in doubt. Count variables were summarized using means (*SD*) despite non normality, to reflect the comparison performed during the analysis, which consisted of Poisson or negative binomial regression (depending on variance) with or without truncation (depending on the range of possible values). Multinomial logistic regression was used for categorical variables with more than two categories. If a hierarchical structure could not be specified as part of the analysis, robust standard errors were used.

Agreement between Haemoglobin (Hb) testing modalities was assessed using Lin's concordance correlation (CCC) and Bland Altman plots.[15,16] Subgroup analysis of agreement was performed for FBP Hb values within the range indicating anaemia (Hb < 80 g/L).

Clinically acceptable limits of agreement were set at +/- 5 g/L. Desirable CCC values were determined to be above 0.80.

Analysis was performed using Stata 17 and significance was set at $p < .05$.

3. RESULTS

Over the 2-year period, 1,000 MET calls were recorded for 760 different patients over 777 admissions (743 single admissions and 17 multiple admissions) (see Table 1). The average age of patients on their first admission was 65.3(18.7) years, and 447 (58.8%) were male. In this sample, 107 (14.1%) patients died within 30 days of admission.

Table 1. MET call, admission and patient characteristics

	Medical mean (*SD*) or n (%)	**Surgical mean (*SD*) or n (%)**	**Univariate *p*-value**	**Adjusted *p*-value**
MET calls (n = 1,000)	550 (55%)	450 (45%)		
MET call outcome			.14	.06
Ward	477 (86.7%)	405 (90.0%)		
Critical Care	58 (10.6%)	40 (8.9%)		
Deceased	15 (2.7%)	5 (1.1%)		
Blood Transfusion	30 (5.5)	41 (9.1)	.04	.04
Total Number of tests	2.3 (2.30)	2.4 (2.2)	.24	.22
Admissions (n = 777)	440 (56.6%)	337 (43.4%)		
Number of calls	1.25 (0.56)	1.34 (0.69)	.03	.04
1 MET calls	85 (19.3%)	85 (25.2%)	.049	.04
Patients (n = 760)	426 (56.1%)	334 (43.9%)		
Age at first admission	66.5 (18.0)	63.8 (19.5)	.051	
Males	240 (56.3%)	207 (62.0%)	.12	

Table 2. MET call triggers (n = 1,000)

Trigger	Medical (n = 550)	Surgical (n = 450)	Univariate *p*-value	Adjusted *p*-value
Arrest	20 (3.6)	1 (0.2)	.006	.006
RR	68 (12.4)	25 (5.6)	.001	< .001
O_2 Saturations	44 (8.0)	27 (6.0)	.23	.31
HR	129 (23.5)	93 (20.7)	.36	.22
BP	154 (28.0)	184 (40.9)	< .001	< .001
GCS	66 (12.0)	64 (14.2)	.35	.31
Concern	69 (12.6)	56 (12.4)	.96	.64

Table 3. Tests requested during Metcall (n = 1,000)

Test*	Medical (n = 550)	Surgical (n = 450)	Univariate *p*-value	Adjusted *p*-value
Fbp	252 (45.8)	241 (53.6)	.016	.011
Abg	113 (20.6)	81 (18)	.32	.25
Vbg	214 (38.9)	203 (45.1)	.053	.048
Uec	264 (48)	238 (52.9)	.13	.077
Magnesium	203 (36.9)	147 (32.7)	.16	.19
Calcium	161 (29.3)	126 (28)	.67	.72
Glucose	18 (3.3)	25 (5.6)	.08	.07
Coags	97 (17.6)	106 (23.6)	.02	.03
LFTs	147 (26.7)	115 (25.6)	.71	.56
Troponin	86 (15.6)	67 (14.9)	.93	.94
Group & Hold	34(6.2)	45 (10)	.027	.026

Note. *Multiple tests can be requested.

3.1 MET call characteristics

Of the 777 admissions, 607 (78.1%) generated a single call to the MET with a further 132 (17%) generating two calls. Between 3 and 5 calls were made for the remaining 38 (4.9%) admissions. The mean number of MET calls per admission for surgical patients was significantly higher than for other divisions combined (1.34 vs. 1.25, $p = .03$ (see Table 2).

Of the 1,000 MET calls, hypotension was the most frequent MET call "trigger" (n = 338, 34%) and differed significantly between patients under surgical and medical governance (40.9% vs. 28%, $p < .001$) (see Table 2). Other frequent triggers included heart rate issues (22.2%) and an altered conscious state (13%). MET calls triggered by a change in respiratory rate occurred more often in medical patients (surgical 5.6% vs. medical 12.4% $p = .001$).

3.2 Tests requested

On average, 2.3 ($SD = 2.3$) tests were requested during a MET call, with 31.4% of MET calls generating no requests for blood work at all. The most frequently requested test was UEC (50.2%) followed by a full blood picture (49.3%). Significant differences in the frequency of tests requested between surgical and medical groups were found for FBP (53.6% vs. 45.8%, $p = .016$) and Coags (23.6% vs. 17.6%, $p = .02$) (see Table 3).

At least one of FBP, VBG and ABG tests were requested for 592 MET calls and of these, two or more tests were requested for 370 (62.5%) episodes (see Table 4). No differences were detected in the combinations of FBP, VBG and ABG tests requested between surgical and medical governance ($p = .26$). Of MET calls triggered by hypotension, a full blood picture (FBP) was taken on 166 (49.1%) occasions.

3.3 Agreement between Hb values from different tests

There were 294 MET calls where both FBP and VBG were requested and Hb level obtained. Lin's concordance correlation coefficient (CCC) was 0.986 (95%CI: 0.983, 0.989) and the Bland Altman limits of agreement (LOA) were -9.55 to 4.7 g/L, indicating that VBG values can be up to 9.5 g/L higher than FBP or up to 4.7 g/L lower (see Figure 1).

In the subgroup of n = 50 MET calls with both FBP and VBG results and Hb values (from FBP) < 80 g/L, Lin's CCC was 0.86 (95%CI: 0.795, 0.927) with the lower limit of the 95%CI dropping below the minimum acceptable value. The Bland Altman LOA were -8.67 to 5.77 g/L (see Figure 2).

Table 4. Tests requested during Metcall (n = 1,000)

	Medical (n = 550)	Surgical (n = 450)	Univariate *p*-value	Adjusted *p*-value
Combination			.26	.22
None	231 (42)	177 (39.3)		
ABG alone	44 (8)	21 (4.7)		
VBG alone	35 (6.4)	27 (6)		
FBP alone	52 (9.5)	43 (9.6)		
FBP + ABG	43 (7.8)	31 (6.9)		
FBP + VBG	138 (25.1)	145 (32.2)		
VBG + ABG	1 (0.18)	1 (0.22)		
FBP + VBG + ABG	6 (1.1)	5 (1.1)		

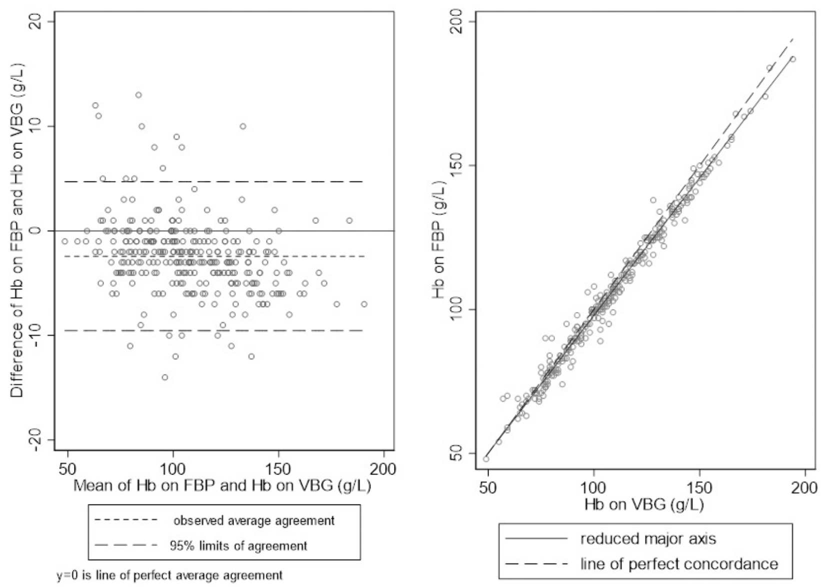

Figure 1. Agreement for full range of Hb values

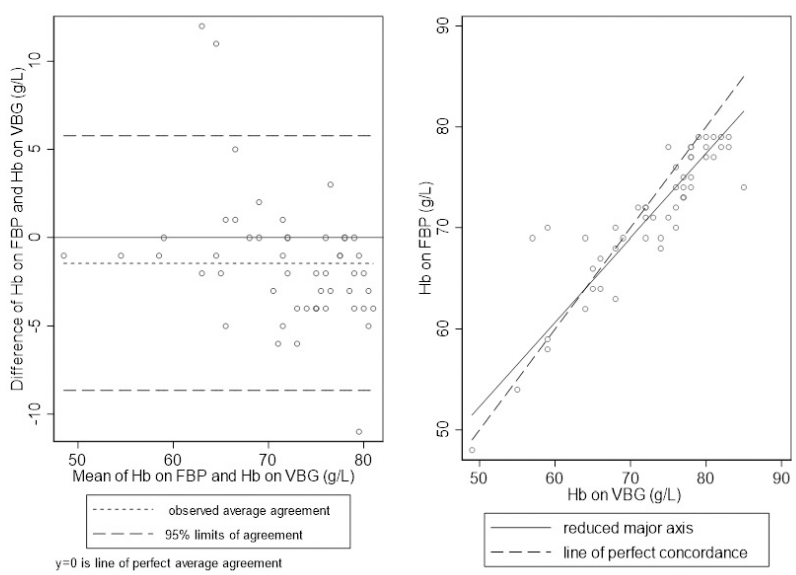

Figure 2. Agreement for Hb on FBP < 80

4. DISCUSSION

Inpatients under medical units and surgical units have different models of governance, especially in medical emergency scenarios of deterioration.[17–19] Surgical patients in our quality improvement initiative were found to have more MET calls. Of interest, was that hypotension was the biggest contributor to MET calls overall and more frequent in surgical inpatients, followed by increased heart rate which was less frequent compared to patients in the medical cohort. Hypotension if not treated will likely lead to adverse outcomes.[20–22] There are many causes of hypotension, such as infection, loss of fluid, loss of blood, hormonal changes and more.[23] Although it may be thought that hypotension in patients after surgical procedures should be expected and therefore addressed, it is interesting to note that in our initiative, it remained a key trigger requiring a MET intervention. The finding that hypotension is more common in surgical patients provides reinforcement for pre-deterioration strategies to minimise patient harm. This may include multi-modal strategies such as crystalloid and colloid intravascular volume products, amongst others.

MET intervention can be considered more of a "strong response" to patient deterioration requiring expert teams to help review and stabilize the patient's condition. Utilization of MET implies that the recognition of MET call triggers did not occur or was not acted upon to try and prevent such a response. In the case of surgical patients, it appears that hypotension is still a deteriorating patient trigger that is either not being recognized as a key contributor to MET calls or that there is an aggressive approach of utilizing MET teams to treat hypotension and other MET call triggers early in such patient cohorts. A MET team is an expensive resource, and the expertise should be utilized across patient care effectively. This initiative suggests that further analysis is needed in reviewing MET call triggers, especially hypotension, and these findings may be applicable to similar tertiary level healthcare settings.

Analysis comparing FBP and VBG indicated strong agreement between the two tests for the Haemoglobin level suggesting that one test is potentially adequate to measure Hb. However, in those with Hb < 80g/L a lower degree of agreement was observed, probably due to the lower sample size. From a treatment decision perspective, if the Haemoglobin value is > 80 g/L, the error margin determined by the limits of agreement would have minimal impact on treatment outcome of transfusion. However, there is potential ambiguity if the Hb level is around the value of 80-90 g/L as it would be unclear whether this is actually in the range of 70-80 g/L. In this scenario, it is unusual for a single laboratory result to determine treatment but rather a combination of inpatient clinical context, patient examination of other symptoms as well as disease etiology.[23]

The levels of agreement observed suggest that clinicians should consider whether using one investigative modality is practicable, if haemoglobin is the key parameter to be determined. Given that, a VBG has a shorter laboratory analysis and reporting time (15min vs up to 60min for FBP), resulting in less delay in decision making relating to patient care, VBG should be considered before FBP. As always, clinical context and senior decision making should guide best practice inpatient care, but it is noted that often at MET calls, multiple investigative modalities are being used, such as both FBP and VBG, where a single laboratory test such as a VBG might suffice for treatment decisions.

Strengths and limitations

Our quality improvement initiative has several limitations. The data collection was performed within a single tertiary level setting and focused on adult inpatient care. In addition, blood testing was performed by a single laboratory, and methodology can be different at other laboratories. Further research is needed at multi-centre sites to increase sample size to power planned sub-group analyses. However, the findings could be applicable to other similar sized healthcare settings and serves as an introductory exploration for other healthcare settings to focus on similar value-based healthcare strategies.

5. CONCLUSION

This quality improvement initiative has highlighted that a focus on deteriorating patients and MET calls is an area of value-based healthcare improvement. This study demonstrates that met call triggers are different in patients under medical and surgical governance, and hypotension, despite being an expected issue in such surgical patient cohorts, is still a prevalent reason for MET intervention. Strategies to manage hypotension in such a cohort should be considered to potentially minimise MET intervention where appropriate.

In addition, this initiative found that often, multiple laboratory investigations, both FBP and VBG were being taken at MET interventions. VBG should be considered as potentially the test of choice at a MET intervention if haemoglobin values are desired. However, this should always be done with the clinical context of the situation and senior clinical decision making, but this finding is of interest to healthcare practitioners with a focus on value-based healthcare.

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AUTHORS CONTRIBUTIONS

All authors contributed equally to the study. All authors read and approved the final manuscript.

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CONFLICTS OF INTEREST DISCLOSURE

The authors declare they have no conflict of interest. This quality improvement initiative was approved by the Hospital Operations and Logistics Access Divisional Committee at Royal Perth Hospital, under registration QI: 39013, and approved for publishing with approval reference number 289.

INFORMED CONSENT

This was done as part of the quality improvement initiative.

ETHICS APPROVAL

The Publication Ethics Committee of the Sciedu Press.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

PROVENANCE AND PEER REVIEW

Not commissioned; externally double-blind peer reviewed.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

DATA SHARING STATEMENT

No additional data are available.

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