Principles of the Justice in Health Care Foundation[4]

Health—Health systems should pursue health as their primary goal
Access—Health systems should provide care primarily according to need rather than ability to pay
Accountability—Consumers, providers, and healthcare institutions must take responsibility for health and healthcare resources with which they are entrusted
Choice—Consumers must have the real ability to choose their healthcare systems, providers, and treatments in order to seek the best value in health care for themselves
Education—Education of consumers, providers, and institutions regarding value and quality in health care is necessary for responsible and informed health choices

personal decisions that reflect personal values as well as medical knowledge.[5] Accountability for the consequences of healthcare decisions is a cornerstone principle. It includes responsibilities of consumers as well as of payers and providers. Taking personal responsibility for our own health, as consumers, means paying according to our means; prudently and appropriately using limited healthcare resources; adopting health promoting behaviours; continually learning about important health issues; and actively participating in decision making about our own health as well as that of the community. This draws consumers into the healthcare system as partners, not just as payers or subjects of care.

By including and preferably emphasising the legitimate needs and obligations of the consumer, we can devise and implement what the Tavistock Group referred to as "a clear, strong, and reasonable set of principles for conduct that *all* [authors' emphasis] stakeholders who give or shape health care can recognise and accept as guides to correct action."[1] Who has more at stake than the patient?

DMM is a member of the board of directors and JEB is the president of the Justice in Health Care Foundation, in Memphis, Tennessee.

Competing interests: None declared.

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Quality Improvement Report

Linking guideline to regular feedback to increase appropriate requests for clinical tests: blood gas analysis in intensive care

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BMJ 2001;323:620–4

Abstract

Problem Need to decrease the number of requests for arterial blood gas analysis and increase their appropriateness to reduce the amount of blood drawn from patients, the time wasted by nurses, and the related cost.
Design Assessment of the impact of a multifaceted intervention aimed at changing requests for arterial blood gas analysis in a before and after study.
Background and setting Twenty bed surgical intensive care unit of a tertiary university affiliated hospital, receiving 1500 patients per year.
Key measures for improvement Number of tests per patient day, proportion of tests complying with current guideline, and safety indicators (mortality, incident rate, length of stay). Comparison of three 10 month periods corresponding to baseline, pilot (first version of the guideline), and consolidated (second version of the guideline) periods from March 1997 to August 1999.
Strategies for change Multifaceted intervention combining a new guideline developed by a multidisciplinary group, educational sessions, and monthly feedback about adherence to the guideline and use of blood gas analysis.
Effects of change Substantial decrease in the number of tests per patient day (from 8.2 to 4.8; $P<0.0001$), associated with increased adherence to the guideline (from 53% to 80%, $P<0.0001$). No significant variation of safety indicators.
Lessons learnt A multifaceted intervention can substantially decrease the number of requests for arterial blood gas analysis and increase their appropriateness without affecting patient safety.

Introduction

Expenditure due to laboratory testing increases continuously and represents up to 25% of the cost of caring for patients in intensive care units.[1] Intensive care medicine accounts for a considerable proportion of hospital resources,[2] and its cost rises as new therapeutic and diagnostic methods are developed.[3] Blood tests can induce iatrogenic anaemia in patients,[4,5] are time consuming for staff, and are costly. Arterial blood gas analysis is the most commonly performed laboratory test in intensive care units.[6 7] Indications for analysis are often left to clinical judgment without reference to any written protocol.

Background

Outline of problem

In our surgical intensive care unit, 46 000 arterial blood gas analyses were performed each year. A one week prospective study showed that over half of these tests could not be justified clinically. In addition, 96% of requests were left to the discretion of the nursing staff, while clinical signs such as respiratory rate or altered pattern of breathing were seldom taken into account in deciding whether the test was necessary. Values of percutaneous oxygen saturation from pulse oximetry were rarely used, even though they match arterial measurements. These findings led us to set up an intervention aimed at reducing the number of requests.

Outline of context

The intervention was conducted in the surgical intensive care unit of a 1200 bed tertiary, university affiliated hospital. The 20 bed unit receives 1500 patients per year for postoperative care after major surgery, multiple trauma, neurosurgery, and organ transplantation for a total of 5300 hospital days. The team comprises three senior intensive care specialists, 10 physicians in training, and 71 nurses (69% certified in intensive care nursing, 15% in second year training, and 15% in first year training). Blood gas analysis is performed at the patient's bedside with three Stat Profile Ultra machines (NOVA biomedical, Waltham, MA) located in the unit. All patients are equipped with a pulse oximeter for monitoring of percutaneous oxygen saturation. Capnography is not used in the unit because it is not reliable in critically ill patients.[8] Arterial catheters are inserted in most patients as clinically required.

Assessment of problems

Detail of approach

Guidelines and feedback have been proposed in the literature as a means of changing ordering habits for routine blood gas analysis. A guideline specifies the rules to apply when performing analyses and helps the user to make an adequate decision.[9–11] Feedback, either concurrent[12 13] or retrospective,[14] allows users to correct their behaviour. It can be provided on a regular basis[12 13] or triggered by thresholds.[14] It can focus on adherence to rules[13] or on impact on volumes[14] or costs[12] of laboratory tests.

To improve the use of blood gas analysis, we designed a multifaceted intervention[15] that combined a new guideline, educational sessions, and feedback. To achieve consensus of all involved parties and facilitate acceptance of the guideline, this intervention was carried out by a multidisciplinary group.[16]

Guideline development

A pilot version of the guideline was designed locally by a group comprising one intensive care consultant, one intensive care senior registrar, three nurses (certified and in training), and one respiratory therapist. From October to December 1997, the group met weekly to define the decision making process underlying the measurement of three blood gas parameters (pH, Pao_2, $Paco_2$). The guideline was developed on a consensus basis[17] as an extensive literature search in the Cochrane Library and Medline did not identify any suitable guideline.

The pilot guideline, which included a comprehensive time frame and the use of pulse oximetry, was devised as an algorithm based on three pathways corresponding to pH, Pao_2, and $Paco_2$ and included a minimum number of three mandatory analyses per

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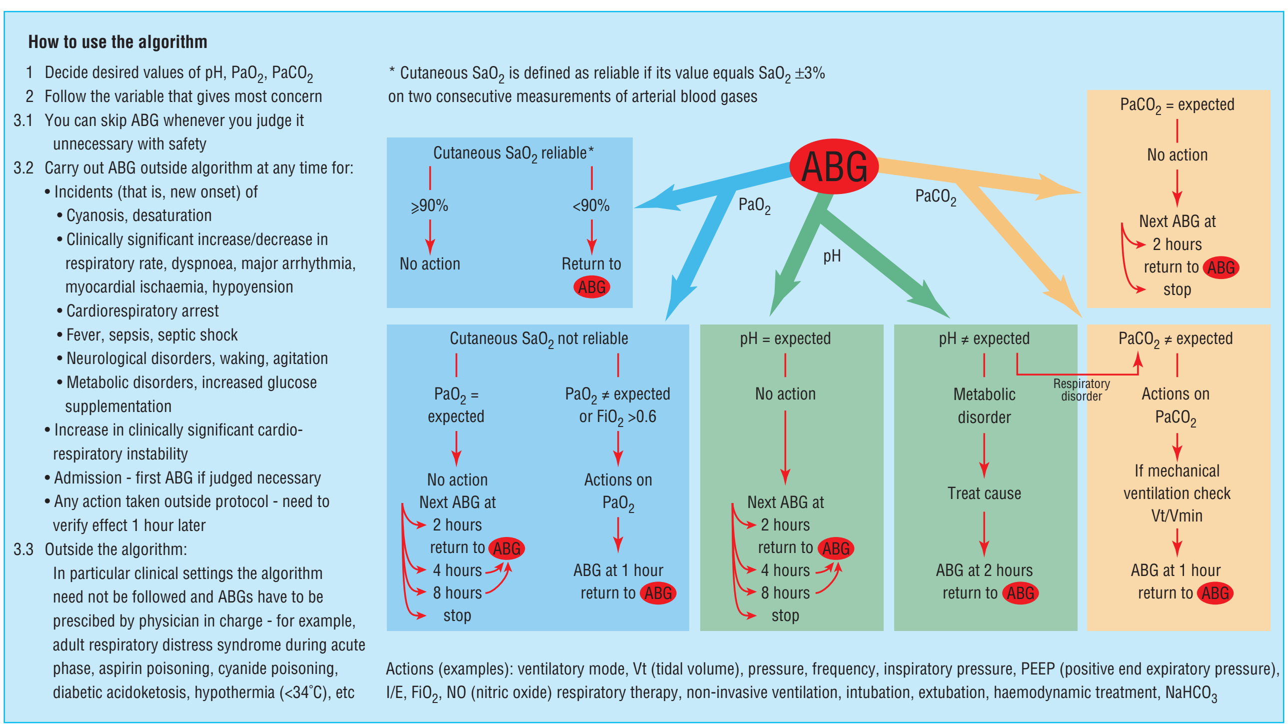

Fig 1 Algorithm for requests for arterial blood gas analysis (translated from French)

day for safety reasons. The guideline was approved by the two other unit consultants.

To incorporate the opinion and the experience of the users we amended the pilot version of the guideline ten months later. In this consolidated version, the time frames were widened and the daily mandatory tests removed. We added a list of clinical settings in which the algorithm should not be applied. The consolidated guideline was validated by four critical care experts from outside the unit (fig 1).

Intervention

Both pilot and consolidated guidelines were distributed as pocket-sized documents and were displayed next to blood gas analysers. They were introduced to all team members in the surgical intensive care unit during 45 minute teaching sessions twice a week over one month. In addition, all new team members were individually instructed when they arrived in the unit.

Feedback was given to the whole team by using two indicators. The adherence indicator revealed deviations from the guideline and the blood gas indicator showed the impact of increased adherence, defined here as appropriateness,[11] on the use of blood gas analysis. Both indicators were presented systematically each month, plotted as time series charts, displayed on walls, and published in the unit information bulletin.

Measurement of problem

Intervention assessment and data collection

We compared three consecutive ten month periods (baseline, pilot, consolidated). They were separated by the dissemination of the pilot version and the consolidated version of the guideline, respectively. Data were obtained retrospectively for the baseline period and prospectively for the pilot and consolidation periods and tabulated monthly.

A first set of data was obtained by sampling one day a month (the audit day). For all patients who were in the unit on that day, two investigators independent of the care team collected data on age, the simplified acute physiology score, version 2 (SAPS II)[18] as a measurement of the severity of illness, and the type of surgery. They individually assessed the proportion of blood gas analyses that complied with the guideline (adherence). All results were checked between the two observers and each disagreement was discussed to achieve consensus. As undetected severe acidaemia or hypoxaemia might lead to major cardiac arrhythmia, cardiac or respiratory arrests, new episodes of pH <7.25, or systolic systemic blood pressure <80 mm Hg, any such incidents were recorded by the attending nurse on the electronic chart. Two independent reviewers computed the number of incidents per day (incident rate) at the end of the patient's stay in the unit to assess the safety of the implemented procedure. Results were compared between the two reviewers, and all discrepancies were double checked and corrected. For patients who stayed long enough to be involved in two consecutive audits, the incident rate from one audit was used.

A second set of data consisted of aggregates extracted from the hospital information system for the whole unit. We tabulated the monthly average number of blood gas analyses per patient day, the average number of all other tests performed per patient day

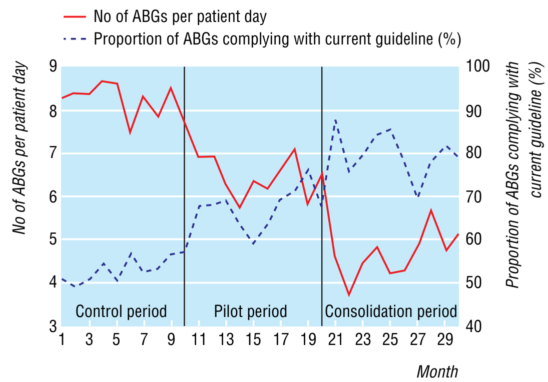

Fig 2 Monthly change in absolute number of arterial blood gas analyses per patient day and proportion of tests adhering to current guideline from baseline (before implementation of pilot guideline), pilot period (after introduction of pilot guideline), and consolidation (after implementation of consolidated guideline)

(other tests), and the average length of stay. In addition, we extracted from the hospital information system, the mortality for the whole unit population for the three periods. For a given month, the average adherence observed during the corresponding audit day served as adherence indicator, whereas number of tests per patient day was used as the arterial blood gas indicator.

Cost-benefit analysis

We calculated benefits associated with increased appropriateness of requests in terms of amount of blood taken (5 ml per test), nurse working days (4 minutes per test), number of analyses per patient day, and corresponding costs (SFr 20 (£8) per test). We assessed the cost of the whole intervention, including meetings, teaching sessions, and reviews, in terms of collaborators' time (number of hours).

Statistical analysis

To perform statistical comparisons, we grouped monthly data together within each period. All variables were compared by the Kruskal-Wallis test except for

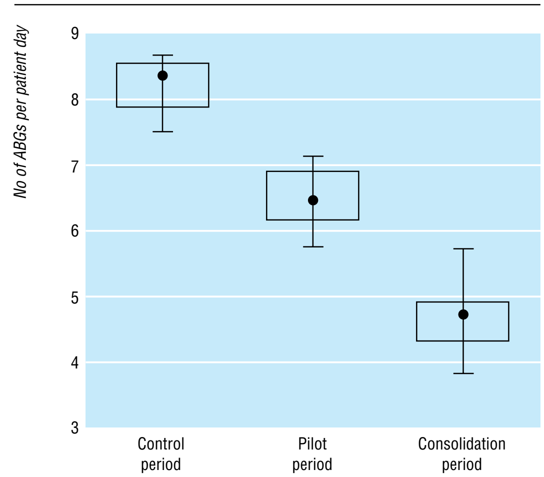

Fig 3 Number of arterial blood gas analyses per patient day per 10 month period (median with minimum and maximum values; 25th and 75th centiles indicated by box plot). P<0.001 for comparison of three periods (Kruskal-Wallis)

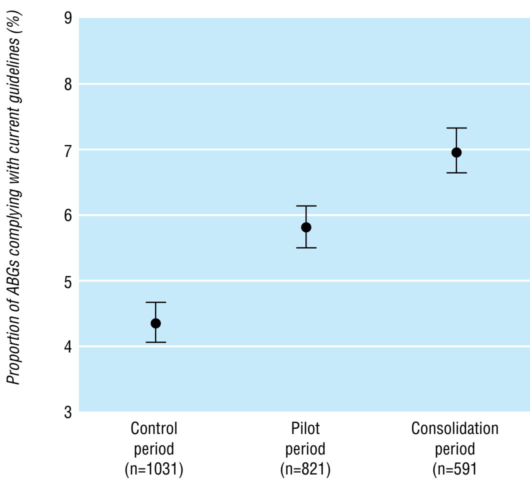

Fig 4 Adherence to guideline per 10 month period (percentage with 95% confidence intervals). P<0.0001 for comparison periods (Pearson's χ^2)

adherence, mortality, and type of surgery, for which we used Pearson's χ^2 test. Data analyses were performed with SPSS release 9.0. $P < 0.05$ was considered significant.

This study was approved by our institution's ethical committee for human research, who authorised a waiving of informed consent. The whole programme was followed and supervised by the Hospital Quality of Care Unit.

Results of assessment

Feedback

Figure 2 shows the time series chart reported monthly to the whole team. It shows the regular decrease of the blood gas analysis indicator and the concomitant increase of the adherence indicator after the introduction of the pilot and subsequently the consolidated guideline.

Impact of the intervention

During the three periods, the characteristics of the patient population studied remained unchanged with regard to age, acute physiology score, and type of surgery (table). Between baseline and pilot periods, the average number of blood gas analyses decreased from 8.2 to 6.5 per patient day (fig 3), whereas the average adherence rose from 53% to 68% (fig 4). Between pilot and consolidation periods, the average number of tests further decreased from 6.5 to 4.8 (fig 3) and the average adherence rose from 68% to 80% (fig 4).

The numbers of all other tests performed in the unit did not vary significantly during pilot and consolidation periods (mean (SD) 20^4, 24^2, and 22^2 for the three periods respectively, $P = 0.05$). The incident rate, length of stay, and mortality remained unchanged throughout the study (table).

Cost-benefit analysis

Per patient day, this reduction resulted in savings of 8.5 ml and 17 ml of patients' blood, 6.8 and 13.6 minutes of nurse working time, and SFr 34.8 (£14.15) and SFr 68.4 (£27.81) in test costs for the two periods, respectively. The global reduction in requests for blood gas analysis during the 20 month study therefore resulted in savings equivalent to 112 litres of patients' blood, 187 nurse working days, and SFr 452 600 (£180 369).

The total cost of the intervention was SFr 79 050 (£31 502) (or SFr 9 (£3.60) per patient day), representing 710 hours for nurses, 270 hours for respiratory therapists, and 400 hours for physicians. Follow up of the process—that is, monthly collection and report of the number of tests—can be carried out by one person at negligible cost (four hours a month).

Lessons learnt

Human factor specialists have shown that deficiencies of attention or reasoning are common and that even experienced and responsible professionals can err. To prevent errors, the use of an explicit model such as a guideline is essential in complex decisions.[19] However, guidelines can be rejected because of their content or

Details of introduction and implementation of guideline on use of arterial blood gas analysis in each 10 month period: baseline (before study), pilot (after first version of guideline), and consolidation (after final version of guideline)

	Baseline	Pilot	Consolidation	P value
Data from audit days (patient sample)				
No of patients	189	176	184	
Mean (SD) age (years)	55 (19)	58 (17)	57 (17)	0.49*
Mean (SD) SAPS II	29 (12)	30 (12)	30 (14)	0.29*
Type of surgery (No (%)):				0.19†
Cardiovascular	68 (36)	74 (42)	73 (39)	
Pulmonary	20 (10)	15 (9)	14 (8)	
Digestive	39 (21)	29 (16)	33 (18)	
Neurosurgical	39 (21)	27 (15)	46 (25)	
Other	23 (12)	31 (18)	18 (10)	
Mean incident rate (70th and 90th centiles)‡	0.22 (0.20, 0.66)	0.36 (0.22, 0.88)	0.19 (0.18, 0.67)	0.85*
Information system data (unit population)				
No of months	10	10	10	
Mean (SD) stay (days)	4.6 (0.5)	4.3 (0.4)	4.3 (0.5)	0.26*
No of patients	1276	1356	1403	
Mortality (%) (95% CI)	7.1 (5.7 to 8.5)	7.2 (5.8 to 8.6)	6.6 (5.3 to 7.9)	0.80†

SAPS II: simplified acute physiology score, version 2.
*Kruskal-Wallis test.
†Presented as such because scarcity of incidents induced skewed distribution.
‡Pearson's χ^2.

Key learning points

Acceptance of the guideline was facilitated because it was developed by a local multidisciplinary group; based on the available scientific evidence and local habits; simple and user friendly; disseminated via pocket sized documents, posters, and educational sessions

The impact of the guideline on requests for blood gas analysis was enhanced by combining iterative education and regular information through ongoing feedback from multiple sources (posters, oral presentations, local information bulletins)

Feedback comprising test volume and adherence to the guideline helped the whole team to recognise the relation between the improved use of blood gas analysis and the reduction in the number of requests

Changing professional behaviour requires long term effort and commitment

format, especially if users are not involved in their design. Allowing users to participate in the revision of this guideline facilitated its acceptance in our project. By providing monthly feedback, both on use of blood gas analysis and on appropriateness through multiple sources over 20 months, we stimulated learning and education in users. In particular, we were able to show that when the guideline was applied, it could result in a safe reduction in the number of requests. As proposed by others,[15] our results favour the combination of multiple approaches in attempts to change professional practice.

The goal of quality improvement projects is not to show without any bias that a specific pinpoint intervention is instrumental in changing practice, especially when already convincing methods are available.[15] It aims much more at making this change happen. This requires a managerial approach, combining strategies and dealing with local resources and barriers. We therefore opted for a long term approach that facilitated the implementation of our guideline, using periodic measurements and feedback. As a consequence, less attention was paid to strict control of any bias. For instance, we chose a before and after study design, as well as retrospective data for establishing baseline, and we did not examine the question of inter-rater reliability. However, the decrease in the use of blood gas analysis can hardly be attributed to external independent factors. Indeed, patient characteristics remained stable and the number of all other tests performed in our intensive care unit did not vary.

Next steps

To maintain the benefits of our intervention, a permanent follow up of this project should be engaged. Firstly, we will set up a periodic revision of our guideline. Indeed, despite satisfying the requirements regarding the methodological standards on guideline development and format recently published in two major medical journals,[20 21] our guideline was based on a consensus of experts. Therefore it could benefit from regular reviews of the literature, and its rating on the scale of evidence could be progressively increased. Secondly, we will replace the time consuming monthly audit day with continuous low cost monitoring capable of detecting a decrease in appropriateness of requests. This could be done by using the sole arterial blood gas analysis indicator, which can be easily extracted from our hospital computer system. This indicator could be plotted as a control chart[22] and trigger a measure of appropriateness based on a review of patients' records each time it exceeds a statistically predefined threshold. Coupled to a measure of appropriateness every six months, we should be able to control deviations permanently.

We are grateful to the four experts, Professors Peter Suter and Jean-Claude Chevrolet and Drs Jean-Pierre Revelly and Jean Roeseler, who helped to revising the consolidated guideline, Eric Gremion, Nadia Mehla, Jean-Max Granier for their technical assistance, and the whole surgical intensive care team, who actively participated in this programme.

Contributors: PM and MD designed the protocol, performed the intervention, collected, analysed, and interpreted the data, and wrote the paper. PG designed the protocol, analysed and interpreted the data, performed the statistical analysis, and wrote the paper. MF performed the intervention, collected, analysed, and interpreted the data, and wrote the paper. BR initiated the project, designed the protocol, collected, analysed, and interpreted the data, wrote the paper, and is guarantor of the study.

Funding: Quality of care program, Geneva University Hospital.

Competing interests: None declared.

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(Accepted 3 May 2001)