Journal of Critical Care xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Journal of Critical Care

journal homepage: www.jccjournal.org

Reevaluation of the utilization of arterial blood gas analysis in the Intensive Care Unit: Effects on patient safety and patient outcome ☆

Franziska E. Blum, MD [a,*], Elisa Takalo Lund, MS [a], Heather A. Hall, MD [b], Allan D. Tachauer, MD [a], Edgar G. Chedrawy, MD, MSc [c,d], Jeffrey Zilberstein, MD [a,e]

[a] Department of Internal Medicine, Weiss Memorial Hospital, affiliate of the University of Illinois, Chicago, IL
[b] Department of Vascular Surgery, Weiss Memorial Hospital, Chicago, IL
[c] Department of Cardiovascular and Thoracic Surgery, Weiss Memorial Hospital, Chicago, IL
[d] Department of Cardiothoracic Surgery, University of Illinois–Chicago at Chicago, Chicago, IL
[e] Department of Medicine, Section of Pulmonary, Critical Care, Sleep and Allergy, University of Illinois–Chicago at Chicago, Chicago, IL

ARTICLE INFO

Keywords:
Arterial blood gas
Ventilator days
Routine testing
Unnecessary testing
Intensive care unit

ABSTRACT

Purpose: Arterial blood gas (ABG) analysis is a useful tool to evaluate hypercapnia in the context of conditions and diseases affecting the lungs. Oftentimes, indications for ABG analysis are broad and nonspecific and lead to frequent testing without test results influencing patient management.
Materials and methods: Electronic charts of 300 intensive care unit (ICU) patients at a single institution were reviewed retrospectively. Reassessment of indications for ABGs led to a decrease of the number of ABGs in the ICU between March and November 2012. Data relating to ventilator days, length of stay, number of reintubations, mortality, complications after arterial puncture, demographics, and medications in 159 ICU patients between December 2011 and February 2012 (group 1) were compared with 141 ICU patients between December 2012 and February 2013 (group 2). Subgroup analysis in ventilated patients was performed.
Results: A decrease of number of ABGs per patient (6.12 ± 5.9, group 1 vs 2.03 ± 1.66, group 2 in ventilated patients; $P = .007$) was found along with a decrease in the number of ventilator days per patient ($P = .004$) and a shorter length of stay for ventilated patients in group 2 compared with group 1 ($P = .04$).
Conclusion: A significant decrease of ABGs obtained in the ICU does not negatively impact patient outcome and safety. A decrease in the number of ABGs per patient allows cost-efficient patient care with a lower risk for complications.

1. Introduction

Respiratory depression is a potentially lethal condition and has received much attention in the literature [1]. Hypercapnia is a direct indicator of respiratory depression, and arterial blood gas (ABG) analysis is an accurate and reliable tool to evaluate hypercapnia in the context of respiratory diseases and conditions affecting the lungs [2]. Most ABG samples are obtained in the Intensive Care Unit (ICU). Ideally, an ABG sample should be obtained, when the results are highly likely to influence patient management [3]. Common indications for ABG sample are the need to evaluate the adequacy of patient ventilation, the need to quantify the response to therapeutic or diagnostic interventions, monitoring of severity and progression of documented disease process, and the assessment of acid base status [4]. The current literature suggests that indications for ABG analysis should be based on the clinical assessment of the patient.

Arterial puncture for ABG analysis is an invasive procedure; and potential complications include occlusion of the artery, digital embolization leading to digital ischemia, sepsis, local infection, pseudoaneurysm, hematoma, bleeding, and skin necrosis [5]. Arterial blood gas samples are frequently obtained for reasons such as change in ventilator settings, a respiratory or cardiac event, and as routine testing [3]. In 2007, Melanson et al [3] determined the utilization of ABG analysis in a tertiary care hospital by having physicians and nurses fill out a utilization survey inquiring about the level of training of the ordering clinician, reason for ordering ABG, and the effect of the results on patient management. The study showed that 79% of ABG test results were expected; a change in patient management based on the ABG results occurred in 42% of cases; and ABG analysis was frequently performed on a routine basis or to assess parameters, which can potentially be assessed clinically or through other measures, such as capnometry [3].

Arterial blood gas analysis is a costly intervention and can lead to serious complications for the patient [3,4]. The current literature does not sufficiently reflect if a cost-efficient utilization of ABG analysis through significant reduction of the number of ABG samples affects

☆ Conflict of interest disclosure: The authors declare that they have no financial and other conflict of interest related to the submitted manuscript.

* Corresponding author at: Department of Internal Medicine, Weiss Memorial Hospital, 4646 North Marine Drive, Chicago, IL 60640. Tel.: +1 7735647400; fax: +1 7735645226.
E-mail address: fblum@weisshospital.com (F.E. Blum).

http://dx.doi.org/10.1016/j.jcrc.2014.10.025
0883-9441/

patient outcome and patient safety. This study determines the effect of reconsideration of the indications for ABG analysis, on patient outcome and safety.

2. Methods

2.1. Data collection

The study was conducted at Weiss Memorial Hospital, an academic teaching hospital and affiliate of the University of Illinois at Chicago, with a 16-bed multidisciplinary ICU. A total of 300 patients were included in this retrospective data review. With the goal to provide excellent yet cost-efficient patient care, the indications to obtain an ABG sample in the ICU (including, for example, change in ventilator settings, respiratory or cardiac event, routine testing, metabolic event, postintubation and postextubation as well as preintubation and preextubation, follow-up on abnormal test results, unreliable pulse oximetry data, and altered mental status) were reevaluated based on an evidence-based review of the literature between March and November 2012. This change in the ICU model included intensivist-led team discussion between attending physicians, resident physicians, and nursing staff during rounds, assessing the indication to obtain an ABG for each individual patient and individual clinical situations based on the question if the results from an ABG analysis would lead to a change in patient management. The decision to obtain an ABG sample was made based on the assessment of the patient rather than routine daily ABG sampling, which included physical examination; ventilator parameters; and the awakening, breathing, coordination, delirium screening, and exercise/early mobility assessment [6]. Before this change in practice was introduced in daily patient care, ABG analysis was commonly ordered by single health care providers with various levels of experience as a matter of routine and without an intensivist-led team assessment of the indication for ABG analysis based on the question if test results are likely to lead to change in patient management. To determine the effect of this measure on patient outcome and safety, we conducted a retrospective data review for the period between December 2011 and February 2012 (group 1) and between December 2012 and February 2013 (group 2). We included the number of ABG samples obtained in the ICU; number of ventilator days; number of reintubations; length of stay (LOS) in the ICU; 30-day mortality after admission to the ICU; medications including anesthetics and opiate-derived analgesics (alprazolam, clonazepam, chlordiazepoxide, diazepam, hydromorphone, lorazepam, morphine, methadone, oxycodone, tramadol, fentanyl, midazolam, propofol, and remifentanil); readmissions to the ICU within the periods mentioned above; complications from arterial puncture; and demographic data including age, sex, Body Mass Index (BMI) as well as cardiac and pulmonary comorbidities. Ventilator days and LOS in the ICU were defined as primary outcome factors. Number of reintubations, 30-day mortality, and complications after arterial puncture were secondary outcome measures. Subgroup analysis was performed in ventilated patients only (66 vs 60 patients in group 1 and group 2, respectively). Data were extracted from Horizon Physician Portal (McKesson Corporation, Chicago, IL) and MIDAS (version 8.1.4; MidasPlus Inc, Tuscon, AZ).

2.2. Statistical analysis

Statistical analysis was performed using SPSS version 21 (IBM Corp, Armonk, NY) and Microsoft Excel 2010 (Redmond, WA). After assessment of the normality of distribution of data collected with the Kolmogorov-Smirnov test, Mann-Whitney *U* test was applied to analyze the differences of ventilator days, LOS in the ICU, reintubation rates, and medications. The *t* test was used to analyze patient age and BMI; and Fisher exact test was applied to assess sex, 30-day mortality, cardiac and pulmonary comorbidities, and regression analysis; and Pearson product correlation was performed. Data are presented as mean ± SD.

This study was approved by the Institutional Review Board at Vanguard Health Chicago Institutional Review Board/Tenet Health Care. Waiver of consent was obtained.

3. Results

A total of 300 patients were included in the study (159 in group 1 and 141 in group 2). Sixty-six patients in group 1 and 60 patients in group 2 were ventilated in the ICU. The number of ABG samples obtained per patient was lower in group 2 (all patients, 3.7 ± 3.7; ventilated patients, 2.03 ± 1.66) (Figs. 1 and 2) compared with group 1 (all patients, 5.5 ± 4.7; ventilated patients, 6.12 ± 5.9) (all patients, $P < .001$; ventilated patients, $P < .001$) (Figs. 2 and 3) (Table 1). A decrease of ABGs of more than 60% per patient was observed for ventilated patients.

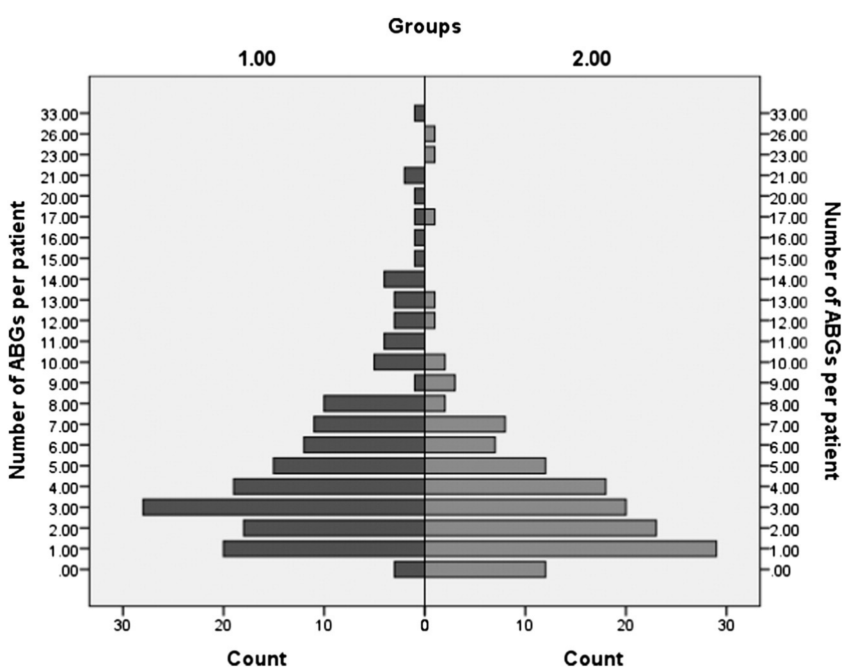

Fig. 1. Count of the number of ABG analysis per patient for all patients in group 1 and group 2.

Please cite this article as: Blum FE, et al, Reevaluation of the utilization of arterial blood gas analysis in the Intensive Care Unit: Effects on patient safety and patient o..., J Crit Care (2014), http://dx.doi.org/10.1016/j.jcrc.2014.10.025