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Current practice of hemodynamic monitoring with PiCCO in a single general surgical ICU in a university hospital - a short report

TATJANA GORANOVIĆ[1,2], VIŠNJA NESEK ADAM[1,2], ELVIRA GRIZELJ-STOJČIĆ[1], MIROSLAVA JAKŠIĆ[1], ANA JADRIJEVIĆ[1,2], MAJA KARAMAN ILIĆ[1,2], MARTINA MATOLIĆ[1]

1 University Department of Anesthesiology, Resuscitation and Intensive Care Medicine, Sveti Duh University Hospital, HR-10000 Zagreb, Croatia
2 Faculty of Medicine, Josip Juraj Strossmayer University of Osijek, HR-31000 Osijek, Croatia

Corresponding author:
Višnja Nesek Adam
Sveti Duh University Hospital
University Department of Anesthesiology, Resuscitation and Intensive Care Medicine
Sveti Duh 64, HR-10000 Zagreb
Phone: 0038513712359
E-mail: visnja.nesek@hotmail.com

ABSTRACT

Background: In recent years, there has been an overall trend toward using less invasive hemodynamic monitoring in surgical intensive care units. The pulse contour cardiac output monitor (PiCCO) is one of them.
Objectives: The aim of this study was to evaluate our practice of hemodynamic monitoring with PiCCO in the perioperative period.
Methods: A retrospective descriptive analysis was performed in a single general surgical intensive care unit (ICU) run by anesthesiologists for the years 2013-2016. We collected information about patients, ICU quality parameters and monitoring equipment available in the ICU. The primary endpoint was the incidence of PiCCO use.
Results: Out of 2972 patients admitted to the general surgical ICU in a 4-year period, besides basic monitoring with electrocardiography (ECG), pulse oximetry and blood pressure monitoring, more than half of the patients received central venous catheterization (55.1%), less than the half invasive arterial catheterization (44.1 %) and only a small proportion PiCCO (0.91%). No patient received a pulmonary arterial catheter. Mortality rate was 7.47 %.
Conclusion: The use of PiCCO in our ICU is far below reported in literature. In the majority of cases, our anesthesiologists make clinical decisions based on measurement of central venous and invasive arterial pressure.

Key words: hemodynamic monitoring, intensive care unit, general surgery

INTRODUCTION

Hemodynamic (HD) monitoring has been regarded as essential monitoring in critically ill patients (1). In the last decades, there was an overall trend to overcome limitations of conventional HD monitoring by introducing more advanced HD monitoring but at the same time less invasive to the pulmonary arterial catheter (PAC) (2,3). The pulse contour cardiac output monitor (PiCCO) from Pulsion Medical Systems (Feldkirchen, Germany) was developed and launched to the market in 1997 (4) as a simple and easier alternative to the PAC (5).
PiCCO uses the single thermal indicator technique and pulse contour analysis to calculate hemodynamic parameters of preload, afterload, cardiac output, systemic vascular resistance and extravascular lung water (6). In addition to showing a very good agreement with the gold standard (PAC) in some studies (7,8), there is evidence that the PiCCO system improved outcomes for patients with severe thoracic trauma and acute respiratory distress syndrome (9).
The purpose of this study was to describe how cardiovascular function was monitored in critically ill patients in our clinical practice. We aimed to evaluate how often PiCCO was implemented by our anesthesiologists.

METHODS

Patients and HD monitoring modalities methods

The Institutional Ethical Committee reviewed and improved the study protocol. The need for informed consent was waived since the study was retrospective. We analyzed data on patients admitted to a single general intensive care unit (ICU) with ideally available six ICU and four high dependency unit (HDU) beds at the University Department of Anesthesiology, Resuscitation and Intensive Care Medicine, Sveti Duh University Hospital, run by anesthesiologists in the period from the beginning of 2013 till the end of 2016.
We used the hospital's and ICU's administration reports to get data about patients (surgery types, severity scores (Simplified Acute Physiology Score (SAPS) II at admittance and discharge), ICU quality parameters (number of mechanically ventilated patients, mechanical ventilation days, use of available ventilators, mortality, use of ICU beds, length of stay in ICU, number of readmittance) and HD monitoring equipment available in the ICU. The primary endpoint was the incidence of PiCCO use during the 4-year study period.

Statistical analysis

We performed a descriptive analysis of the patients' and HD monitoring modalities' characteristics. For the descriptive statistical analysis, we calculated absolute and relative frequencies (in percentage) to describe categorical data and mean ± standard deviation and median as well as range for continuous data.

RESULTS

During a 4-year study period, there were 2972 admittances. Mortality rate was 7.47 %. Table 1. shows general characterization of the studied ICU. All patients received basic monitoring with electrocardiography (ECG), pulse oximetry and non-invasive blood pressure monitoring. Further HD monitoring was performed in 2983 cases. 1640 (55.1 %) patients received central venous catheterization, 1316 (44.1 %) invasive arterial catheterization and 27 (0.91 %) PiCCO. No patient received a PAC. Table 2. gives details about the used HD monitoring modalities.

Table 1. Characterization of the studied intensive care unit in a 4-year period (2013-2016)

	2013	2014	2015	2016	Total 2013-2016
Admittance	721 (100%)	739 (100%)	731 (100%)	781 (100%)	2972 (100%)
Readmittance	35 (4.85%)	67 (9.07%)	47 (6.43%)	36 (4.60%)	185 (6.22%)
Mechanically ventilated patients	164 (22.75%)	284 (38.43%)	194 (26.54%)	155 (19.85%)	797 (26.82%)
ICU stay/days (mean±SD)	4.19±0.78	4.01±0.41	4.05±0.54	3.62±0.32	3.97±0.4
SAPS II at admittance (mean±SD)	45±23	40±23	45±27	46±28	44±25
SAPS II at discharge (mean±SD)	62±31	62±31	66±34	63±33	63±32
Type of surgery:					
Abdominal	478 (66.30%)	471 (63.47%)	481 (65.80%)	541 (69.27%)	1971 (66.32%)
Trauma / orthopedics	167 (23.16%)	178 (24.10%)	156 (21.34%)	145 (18.57%)	646 (21.73%)
Vascular	64 (8.88%)	59 (7.98%)	66 (9.03%)	67 (8.58%)	256 (8.61%)
ENT and eye	13 (1.80%)	31 (4.19%)	28 (3.83%)	28 (3.59%)	100 (3.36%)
Mortality	63 (8.74%)	52 (7.04%)	59 (8.07%)	48 (6.14%)	222 (7.47%)

Categorical data given in absolute and relative frequencies (in percentage) and continuous data in mean ± standard deviation.
SD, standard deviation
SAPS, Simplified Acute Physiology Score
ENT, ear nose throat

Table 2. Hemodynamic monitoring modality in a 4-year period (2013-2016)

HD monitoring modality	2013	2014	2015	2016	Total 2013-2016
Central venous catheterization	417 (59.32 %)	405 (55.40 %)	435 (53.31 %)	383 (52.25 %)	1640 (54.98 %)
Invasive arterial pressure	278 (39.54 %)	321 (43.91 %)	372 (45.59 %)	345 (47.07%)	1316 (44.12 %)
PiCCO	8 (1.13 %)	5 (0.68 %)	9 (1.10 %)	5 (0.68 %)	27 (0.91 %)
PAC	0	0	0	0	0
Total	703 (100%)	731 (100%)	816 (100%)	733 (100%)	2983 (100 %)

HD, hemodynamic
PiCCO, pulse contour cardiac output
PAC, pulmonary arterial catheter

DISCUSSION

The results of this study show how HD monitoring is performed in a single general surgical intensive care unit in Croatia. We found that basic HD monitoring (ECG, pulse oximetry and non-invasive blood pressure) was performed in all patients, while extended HD monitoring with PiCCO was performed in very rare cases. The first finding about wide use of basic monitoring was expected and in accordance with literature (10). The unit was well equipped with basic monitoring equipment through the study period without interruptions. There was no performance of the PAC since this was a general surgery intensive care unit. The PAC seems to be

reserved, nowadays, mostly for cardiac surgery (11). However, the finding of the very low, almost neglected incidence of the use of PiCCO, and no other extended HD monitoring is remarkable.

There are general recommendations to use extended HD monitoring in high-risk surgical patients (12) and critically ill patients in circulatory shock (13, 14) despite paucity of evidence showing that HD monitoring improves patients' outcomes (1). Indeed, use of any HD monitoring devices per se does not make critically ill patients more likely to survive. However, accurate data measurement and appropriate interpretation of cardiovascular variables may help guide therapeutic interventions, which in turn can improve patient outcomes (12, 13).

A recent multicentre cross section study on patient monitoring in German, Austrian and Swiss ICUs (ICU-CardioMan Study) reported direct therapeutic changes in 71.6% of patients in whom extended HD monitoring was applied (10). The lack of extended HD monitoring exposes our critically ill patients to the risk of not receiving proper therapeutic management.

Specific infrastructural and patients' characteristics of our ICU, as being led by anesthesiologists and not supporting cardiac surgery patients, could partially explain the lower incidence of using PiCCO, as these factors were reported as less strong predictors for the use of extended HD monitoring (10).

Availability of PiCCO in ICU does not necessarily lead to its use. The ICU-CardioMan Study (10) reported that the use of extended HD monitoring based on transpulmonary thermodilution (technology used by PiCCO) was available in 96.1% in ICUs led by anesthesiologists. However, the incidence of 19% for using transpulmonary thermodilution technology was low and the use of semi-invasive including an auto calibrated pulse contour analysis was very low (3.5%). In one questionnaire study about the use of HD monitoring in high-risk surgery patients, European anesthesiologists reported to use global end diastolic volume (one of PICCO variables) in 8.2%, while North American anesthesiologists reported to use it in 2.1% (15). This difference is not easy to explain because potential causes may be missing confidence in monitoring accuracy and some other reasons such as economic that influence availability of a specific device. Whatever reason for the discrepancy of the incidence of using PiCCO might be, compared to the above reported data, our incidence of 0.91 % seems extremely low.

A potential reason for the low incidence of using PiCCO in our ICU may be lack of implemented HD treatment protocol with PiCCO. The authors of the ICU-CardioMan Study reported also that HD treatment protocol was implemented in 67.5% of patients with septic shock in ICUs lead by anesthesiologists. We follow general sepsis guidelines, but contrary to the fluid management recommendation (12), we also measure filling pressures by central venous catheterization in selected patients. We would rather leave the possibility to choose the type and extent of HD monitoring to the discretion of an attending ICU physician. It is interesting that filling pressures were the main tool for the assessment of preload in the ICU-CardioMan Study (10) and some other recent studies (16,17). The French study also reported variability in HD monitoring between ICU centers (16).

Already reported disadvantages of PiCCO difficulties in learning (18), the need for frequent recalibration (6), uncertainty regarding the physiological significance of derived variables under a wide range of hemodynamic perturbation (19) may distract clinicians to use it more often. We believe that the main reason for the extremely low incidence of PiCCO use in our ICU setting was financial restrictions and its unavailability in the study period. However, this result was surprising to us too, because as the university department, we have an educational obligation to perform and we have had the perception that we have performed our teaching duties satisfactorily. Moreover, our education obligation is to teach hemodynamics using different modalities, not reserved only on PiCCO. Divergence between subjective perception of higher use reflected in the results of surveys among ICU physicians and the objective assessment based on patient data was already reported (20). It is remarkable to emphasize that the evidence tells against that the affiliation to a university hospital compared with a non-university hospital was an independent predictor for the use of extended hemodynamic monitoring (10).

CONCLUSION

The results of this study showed a disappointing picture of how HD monitoring is performed in a single Croatian general surgery intensive care unit in clinical reality. The use of PiCCO in the studied ICU was far below recommended and reported in the literature due to financial restraints and local equipment unavailability. In a majority of cases, our anesthesiologists make clinical decisions based on measurement of central venous and invasive arterial pressure. However, if wanted to have better insight of cardiovascular function, follow the current clinical guidelines and improve overall quality of treatment of their critically ill patients, the management of the general surgery intensive care unit should perform a thorough analysis of patients' treatment needs to take further steps for implementing advanced HD monitoring.

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