Variable assessment of the circulation in intensive care unit patients with shock

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ABSTRACT

INTRODUCTION: Circulatory failure is frequent in intensive care unit (ICU) patients and is associated with a high mortality and morbidity. There is no current consensus on which parameters best evaluate circulatory failure, and clinical practice regarding haemodynamic assessment is unknown. This study describes current clinical practice regarding circulatory assessment in ICU patients with shock.

MATERIAL AND METHODS: This was a prospective, observational cohort study conducted in a university hospital ICU over a four-month period. Doctors working in the ICU were divided into two groups: trainees and specialists. They registered their circulatory assessments of consecutive patients with shock. The parameters included type of shock, kind of parameters used (markers of hypoperfusion, hypovolaemia and flow), which parameter was considered to be most important and the clinical action taken.

RESULTS: A total of 23 doctors performed 210 patient assessments, which was equivalent to a median of eight (interquartile range: 5-14) per doctor. Trainees used six (5-8) parameters compared with five (3-6) parameters per assessment among specialists ($p < 0.01$). Mean arterial pressure (MAP) was the most frequently assessed parameter ($n = 178$) and both specialist (in 23% of assessments) and trainees (30%) considered MAP to be the most important parameter. Hypoperfusion markers were assessed in 99% of the cases, and a marker of hypovolaemia was also assessed in 83% (95% confidence interval (CI) 78-88) of these cases. Fluid was the most frequent clinical action taken, and was given after 150 assessments, but a marker of hypovolaemia was not assessed in 13% (95% CI 9-20) of these situations. Trainees assessed heart rate (76% versus 54%; $p < 0.01$), diastolic (45% versus 28%, $p < 0.01$) and systolic blood pressure (70% versus 46%; $p < 0.01$) and central venous oxygen saturation (63% versus 35%; $p < 0.01$) more frequently than specialists.

CONCLUSION: MAP was the most frequently used parameter and fluid the most frequently given treatment by ICU doctors assessing patients with shock. The study indicates that assessment of hypoperfusion leads to the use of a marker of hypovolaemia, but in some cases fluid was given without this assessment. The haemodynamic assessment differed between ICU specialists and trainees.

FUNDING: Righospitalet's Research Council supported the study.

TRIAL REGISTRATION: not relevant.

Circulatory failure in intensive care unit (ICU) patients is frequent, difficult to treat and associated with a high mortality [1]. The challenges in treating circulatory failure are that most of the evidence comes from physiological knowledge rather than from well-executed trials with endpoints important to the patient. In addition, many of the studies done to validate the different diagnostic tests have methodological flaws [2]. Therefore, there is no consensus on which parameters provide the best possible evaluation of circulatory failure in patients with shock.

Current clinical practice regarding circulatory assessment is not well-described. A German questionnaire survey described haemodynamic monitoring and therapy after cardiac surgery in 2007 [3]. The main result was that haemodynamic monitoring and therapy varied enormously between ICUs.

Little is known about how assessments and choices of treatment are currently made, and no study has so far described the parameters doctors use when they assess a patient with shock. Knowledge on current clinical practice is necessary in order to advance treatment in this field.

The aims of this study were to evaluate current clinical practice regarding circulatory assessment of ICU patients with shock and to describe the treatments initiated.

MATERIAL AND METHODS

This was a prospective, observational cohort study performed over the course of a four-month period. A registration form covering circulatory assessment was introduced to the doctors at the general ICU at Rigshospitalet. The ICU has its own staff of specialist doctors, and anaesthetist trainees rotate through the unit at 3-6-month intervals. The hospital runs specialized ICUs for cardiac, cardiothoracic, neurosurgical and neurologic cases, so no patients with primary diagnoses within these specialities were assessed. Docters working in the ICU were divided into two groups; trainees and specialists. They were asked to register the parameters they used in their circulatory assessment of the patients they diagnosed with shock. In order to evaluate clinical practice as accurately as possible, the form was to be filled out immediately after the patient assessment. A total of 210 patients were assessed at the time of diagnosis.

ORIGINAL ARTICLE

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Dan Med J 2013;60(9):A4676

TABLE 1

Circulatory parameters used by intensive care unit doctors assessing patients with shock.

Parameter	Assessments, n (%) all (N = 210)	specialist (N = 127)	trainee (N = 83)	p-value[a]
Markers of hypoperfusion				
MAP	178 (85)	112 (88)	66 (80)	0.12
Pulse	132 (63)	69 (54)	63 (76)	< 0.01
Systolic BP	116 (55)	58 (46)	58 (70)	< 0.01
Peripheral perfusion	113 (54)	66 (52)	47 (57)	0.57
Diuresis	108 (51)	57 (45)	51 (61)	0.02
Lactate	92 (44)	53 (42)	39 (47)	0.48
Diastolic BP	72 (34)	35 (28)	37 (45)	0.01
Haemoglobin	40 (19)	20 (16)	20 (24)	0.15
Markers of hypovolaemia				
CVP	59 (28)	37 (29)	22 (27)	0.75
Passive leg raising test	28 (13)	15 (12)	13 (16)	0.53
Arterial waveform analysis	36 (17)	21 (17)	15 (18)	0.85
Markers of flow				
$ScvO_2$	97 (46)	45 (35)	52 (63)	< 0.01
ECHO self	38 (18)	22 (17)	16 (19)	0.72
Cardiac output	23 (11)	18 (14)	5 (6)	0.07
ECHO by cardiologist	16 (8)	9 (7)	7 (8)	0.79

BP = blood pressure; CVP = central venous pressure; ECHO = echocardiography; MAP = mean arterial pressure; $ScvO_2$ = central venous oxygen saturation.
a) Specialists versus trainees.

Each enrolled patient could only be assessed once, and the doctor was only allowed to fill out one form for each patient. The forms were handed in anonymously. The aim for each doctor was to file a total of 15 forms from 15 different patients. At morning and afternoon handovers, doctors were asked whether they had assessed patients during their shift. If they had not filled out a form, this was done retrospectively.

Four major areas were covered: The type of shock including septic, hypovolaemic, cardiac and anaphylactic shock. The use of hypoperfusion markers including mean blood pressure (MAP), pulse, systolic blood pressure, peripheral perfusion, diuresis, plasma lactate, diastolic blood pressure and haemoglobin and the use of hypovolaemia markers, including central venous pressure (CVP), passive leg-raising (PLR) and arterial waveform analyses and the use of flow markers including central venous oxygen saturation ($ScvO_2$), cardiac output (CO) and echocardiography (ECHO).

If none of the above markers were used, the doctor documented what was used instead. If a fluid bolus was given during the initial assessment, the doctor registered if any of the above parameters were reassessed. The doctor was asked which parameter she or he considered to be more important in assessing the patient, and initiation or change in treatments was registered including vasopressors, inotropics, blood or fluid.

Statistics

Variables were expressed as medians with interquartile ranges (IQR) and categorical variables as frequencies and percentages of the total. To compare data between groups, Fisher's exact test was used. Statistical analyses were performed using SAS (Statistical Analysis System) version 9.1.3. $p < 0.05$ was considered the threshold for statistical significance.

Trial registration: not relevant.

RESULTS

During the four-month study period, eight trainees and 15 specialists performed 210 circulatory assessments in ICU patients with shock; 83 were done by trainees and 127 by specialists. The median was eight (IQR 5-14) completed forms per doctor.

A total of 111 patients had septic shock, 85 had hypovolaemic shock and 35 had cardiac shock, consequently some patients had more than on type of shock.

No patients were registered with anaphylactic shock.

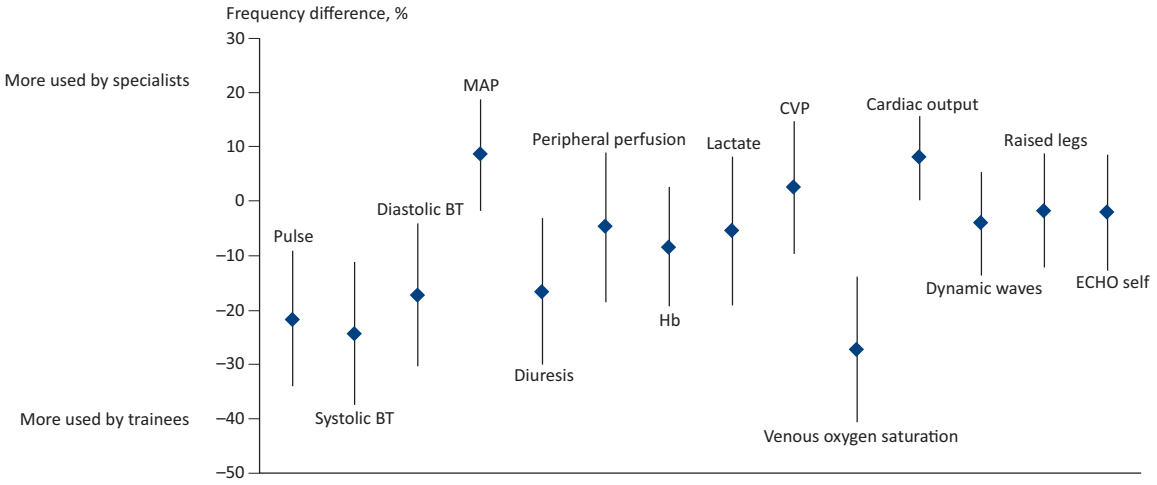
A median of six (IQR 4-8) parameters were used per patient. Trainees used more parameters than specialists (6 (5-8) versus 5 (3-6); $p < 0.01$) per assessment. MAP was the most frequently used parameter (**Table 1**). The most frequent combination of parameters was pulse and MAP which was used 113 times, systolic blood pressure and MAP was used 100 times, and MAP and peripheral perfusion used 97 times. Trainees assessed heart rate (76% versus 54%; $p < 0.01$), diastolic (45% versus 28%; $p < 0.01$) and systolic blood pressure (70% versus 46 %; $p < 0.01$) and central venous oxygen saturation (63% versus 35%; $p < 0.01$) more frequently than specialists, see Table 1 and **Figure 1**.

In 208 of the 210 assessments, at least one hypoperfusion marker was registered, in 173 assessments at least one hypovolaemia marker was registered and in 132 assessments at least one flow-marker was registered. Of the 208 assessments in which hypoperfusion markers were used, 171 patients (82%) were also assessed by a marker of hypovolaemia and 150 (72%) received fluid as a treatment. In 115 assessments (55%), both makers of hypoperfusion, flow and hypovolaemia were assessed.

A total of 67% doctors answered the question which parameter he or she considered the most important in the evaluation of the patient's cardiovascular status. The specialists preferred MAP (23%) and ECHO (19%), whereas the trainees preferred MAP (30%) and $ScvO_2$ (20%). Both groups considered that MAP was the most important parameter.

Treatment was initiated or changed after 183 assessments, see **Figure 2**. Fluid bolus was given a min-

FIGURE 1



Differences in choice of parameters between specialists and trainees for circulatory assesment of shock patients. For each parameter, the difference in use is given as frequency difference (frequency among specialists minus frequency among trainees) in percentages with a 95% confidence interval.

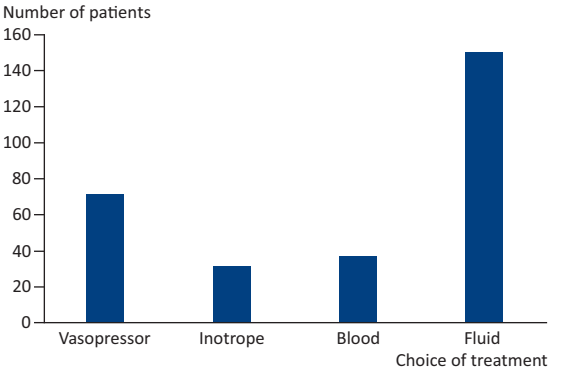
BP = blood pressure; CVP = central venous pressure; ECHO = echocardiography; Hb = haemoglobin; MAP = mean arterial pressure.

imum of 122 times; and in 34 of these assessments, the doctor registered a post-fluid change in one or more parameter (2 (1-3)). A total of 20 patients received fluid (13%; 95% CI 8-19) without prior assessment using a marker of hypovolaemia. Ten of these patients were assessed by trainees and ten by specialists.

Of the 31 patients who received inotropic treatment, flow-marker assessment been given before the inotropic treatment in 21 cases (68%). Among the patients who received blood, 51% had been assessed by $ScvO_2$ prior to their transfusion.

FIGURE 2

Treatments given to intensive care unit care patients with shock after circulatory assessment.



DISCUSSION

To our knowledge, this is the first study describing bedside clinical practice regarding circulatory assessment in the ICU. The principal findings were that doctors in the ICU used a variety of parameters when performing circulatory assessment and that multiple parameters were used at each patient assessment. Furthermore, the choice of parameters differed between ICU trainees and ICU specialists. This could support the hypothesis that ICU doctors' choice of parameters differs according to their clinical experience.

Both specialists and trainees used MAP more frequently than any other marker, and both groups considered MAP the most important parameter during circulatory assessment. MAP is easy to measure and has been shown to be a predictor of mortality in septic shock [1]. Obviously, a reasonable MAP indicates that the patient has some cardiac output (CO) and organ perfusion, which justifies its routine use. On the other hand, MAP or changes in MAP are unlikely to quantify CO, changes in CO or give information about the presence of heart failure or hypovolaemia [4]. In agreement with this, the vast majority of assessments in the present study included both flow and hypovolaemia markers. Nevertheless, assessment of hypoperfusion, flow and hypovolaemia was undertaken in only half of all the patients, and 22 patients had no assessment of flow or hypovolaemia, which may have resulted in sub-optimal care. On the other hand, the clinical assessment of flow and hypovolaemia is hampered by lack of evidence in support of any of these methods. As an example, the measurement of CO did not improve outcome in a large randomized controlled trial (RCT) of ICU patients with shock [5].

Haemodynamic monitoring of an intensive care unit patient.

The lack of hypovolaemia assessment might reflect that this assessment is difficult to perform. CVP is a poor predictor of fluid responsiveness [6], the use of the arterial wave-form analyses is limited to heavily sedated patients on controlled ventilation, and the PLR test is dependent on the evaluation of changes in CO, stroke volume or aortic blood flow, which is not always available at the bedside [7]. On a daily basis, doctors must navigate between patients who may or may not respond to fluid treatment, and the need for accurate diagnostic tests for hypovolaemia is highlighted by the observation that only half of the patients included in trials of fluid responsiveness achieved increased CO when treated with fluid [8-10].

The limitations of this study include that it only represents clinical practice in one ICU; a larger sample size including other hospitals in other regions would increase the study's external validity. Also, we cannot know if the doctors registered results correctly. On the other hand, the method used has advantages compared to a survey because it related to a specific circulatory assessment, which likely reduced the risk of recall bias.

How to advance treatment in this field? The potential of haemodynamic goals combined with a treatment protocol was shown in a landmark, single-centre RCT of early resuscitation in patients with severe sepsis guided by $ScvO_2$ [11]. This protocol is currently being tested in three large, independent RCTs performed on three continents. The results of these RCTs and those of the preplanned individual patient data meta-analysis will give us more definitive answers about the effectiveness of this specific protocol [12]. Such trials and collaborative efforts are needed to establish evidence-based medicine also in the complex area of circulatory assessment and optimisation in ICU patients.

CONCLUSION

MAP was the most frequently used circulatory parameter and fluid the most frequently given treatment by ICU doctors assessing patients with shock. The results indicate that assessment of hypoperfusion leads to the use of a marker of hypovolaemia, but in some cases fluid was given without this assessment. Moreover, only half of the patients had assessments of both hypoperfusion, flow and hypovolaemia. The haemodynamic assessment differed between ICU specialists and trainees.

The ideal combination of parameters for the circulatory assessments of ICU patients with shock remains unknown, and RCTs are needed in this field in order to produce guidelines with a view to improving care for these very sick patients.

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ACCEPTED: 28 May 2013
CONFLICTS OF INTEREST: Disclosure forms provided by the authors are available with the full text of this article at www.danmedj.dk.

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