ISSN 2220-3141 (online)

World Journal of *Critical Care Medicine*

World J Crit Care Med 2018 May 4; 7(2): 31-38

Published by Baishideng Publishing Group Inc

World Journal of Critical Care Medicine

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World Journal of Critical Care Medicine
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AIM AND SCOPE

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INDEXING/ABSTRACTING

World Journal of Critical Care Medicine is now indexed in PubMed, PubMed Central.

NAME OF JOURNAL
World Journal of Critical Care Medicine

ISSN
ISSN 2220-3141 (online)

LAUNCH DATE
February 4, 2012

FREQUENCY
Quarterly

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7901 Stoneridge Drive,
Suite 501, Pleasanton, CA 94588, USA
Telephone: +1-925-223-8242
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E-mail: bpgoffice@wjgnet.com
Help Desk: http://www.f6publishing.com/helpdesk
http://www.wjgnet.com

PUBLICATION DATE
May 4, 2018

INSTRUCTIONS TO AUTHORS
http://www.wjgnet.com/bpg/gerinfo/204

ONLINE SUBMISSION
http://www.f6publishing.com

World Journal of Critical Care Medicine

Submit a Manuscript: http://www.f6publishing.com

World J Crit Care Med 2018 May 4; 7(2): 31-38

DOI: 10.5492/wjccm.v7.i2.31

ISSN 2220-3141 (online)

ORIGINAL ARTICLE

Clinical Practice Study

Confidence level of pediatric trainees in management of shock states

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Institutional review board statement: The study was reviewed by the Institutional Review Board at the Children's National Medical Center Institutional Review Board and certified as "exempt" since it was an anonymous survey sent to trainees and did not involve real patients.

Informed consent statement: The study was exempt from informed consent as it did not involve any patients.

Conflict-of-interest statement: No potential conflicts of interest relevant to this article were reported.

Manuscript source: Unsolicited manuscript

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Received: February 6, 2018
Peer-review started: February 7, 2018
First decision: March 7, 2018
Revised: March 12, 2018
Accepted: April 22, 2018
Article in press: April 22, 2018
Published online: May 4, 2018

Abstract

AIM

To assess overall confidence level of trainees in assessing and treating shock, we sought to improve awareness of recurrent biases in clinical decision-making to help address appropriate educational interventions.

METHODS

Pediatric trainees on a national listserv were offered the opportunity to complete an electronic survey anonymously. Four commonly occurring clinical scenarios were presented, and respondents were asked to choose whether or not they would give fluid, rank factors utilized in decision-making, and comment on confidence level in their decision.

RESULTS

Pediatric trainees have a very low confidence level for assessment and treatment of shock. Highest confidence level is for initial assessment and treatment of shock involving American College of Critical Care Medicine/Pediatric Advanced Life Support recommendations. Children with preexisting cardiac comorbidities are at high risk of

under-resuscitation.

CONCLUSION

Pediatric trainees nationwide have low confidence in managing various shock states, and would benefit from guidance and teaching around certain common clinical situations.

Key words: Fluid bolus; Shock; Medical education; Central venous pressure; Decision-making; Pediatric advanced life support guidelines

Core tip: Pediatric trainees at all levels of training across the United States express a low degree of confidence in management of various types of shock. Children with cardiac comorbidity are at very high risk of under-resuscitation when presenting with shock. Central venous pressure is often used in isolation for decision-making regarding fluid administration and supersedes other subjective and objective measures of intravascular fluid status and shock state.

Morparia K, Berg J, Basu S. Confidence level of pediatric trainees in management of shock states. *World J Crit Care Med* 2018; 7(2): 31-38 Available from: URL: http://www.wjgnet.com/2220-3141/full/v7/i2/31.htm DOI: http://dx.doi.org/10.5492/wjccm.v7.i2.31

INTRODUCTION

Fluid resuscitation of hypovolemic shock has been hailed as acute medicine's great triumph for children[1]. A fluid bolus is one of the most rapid ways to increase cardiac output and is central in the management of many shock states. Recognition and timely resuscitation of shock with fluid is one of the most important aspects of training in pediatrics, and one that all trainees must be empowered to feel confident managing. It has been well established that appropriate early treatment of shock is associated with improved outcomes[2,3]. Pediatric resident and fellow physicians are often the first responders at the bedside of an acutely ill child. They may be assessing the patient for the first time in the emergency room, or might be called upon to assess a patient for a change in vital signs. We were interested in exploring the grey zone in decision-making - everyone would elect to continue fluid resuscitation in the face of obvious hypotension - however, in practice, the blood pressure drops very late in the evolution of shock in children, and we were interested in finding out how trainees navigate the period before profound shock develops.

Though there is some literature on level of adherence to Pediatric Advanced Life Support (PALS) guidelines and outcomes[4,5], there is a paucity of literature on the ability of pediatric trainees to correctly assess and treat shock states of varying etiologies. Variable heart rates and blood pressure thresholds for varying ages in children make it more challenging to recognize deviations from normal, often confounded by factors such as fever and beta agonist administration. While comorbid cardiomyopathy engenders a more cautious approach to fluid bolus administration, fear of fluid overload might hamper adequate resuscitation. The American College of Critical Care Medicine (ACCM) guidelines[6] recommend resuscitation end-points based on the difference between mean arterial pressure (MAP) and central venous pressure (CVP), mixed venous saturation ($ScVO_2$) and hemoglobin level, along with clinical exam findings. CVP has long been shown to have no utility as a marker of fluid responsiveness, yet continues to be considered as a factor in decision-making. We framed these potential stumbling blocks as clinical situations that may be widely prevalent in clinical practice as a survey for a nationwide sample of pediatric trainees. We sought to assess the confidence level of residents in the assessment and treatment of shock.

Our aim in performing this research was to assess overall confidence level of trainees in assessing and treating shock. We sought to improve awareness of recurrent biases in clinical decision-making to help address appropriate educational interventions. There is extensive literature on cognitive biases affecting decision-making in medicine[7,8], however we are not aware of any studies dealing with decision-making aspects in the management of children in the emergency room or critical care environment. There are situations where closer supervision and clinical guidance may improve earlier detection of shock in the critically ill child.

MATERIALS AND METHODS

We designed a survey tool using REDCap[9], an online electronic survey tool. We obtained approval from the Institutional Review Board at the Children's National Health System and by the American Academy of Pediatrics (AAP) Section on Medical Students, Residents and Fellowship Trainees (SOMSRFT). The survey was then distributed via the AAP SOMSRFT listserv to all members currently having valid email addresses and registered with this section of the AAP, with an additional reminder email after a few weeks. Participation in the survey was voluntary and anonymous.

We collected demographic information including current role (medical student, resident or fellow), level of training based on postgraduate year (PGY-1, 2, 3, *etc.*) and area of specialty (for fellows). This was followed by four hypothetical case scenarios based on the recognition and management of shock. Table 1 details the clinical case presented and expected outcomes. The clinical description was followed by a set of questions including (1) Course of action the trainee would choose: fluid/

vasoactive/neither/other; (2) clinical factors taken into consideration - ranked on a Likert scale for importance; (3) level of confidence in decision ranked on a Likert scale; and (4) comments/reasoning if any. We performed additional analysis after stratification of the respondents into two groups - experts and non-experts. We classified fellows in pediatric critical care, pediatric emergency medicine and pediatric hospital medicine as experts in fluid resuscitation. All other respondents were non-experts.

Statistical analysis

Data were directly available on REDCap, and descriptive statistics were generated using this tool. Additional statistical functions were performed using SPSS v 21.0 (IBM). We used the χ^2 test to detect differences in categorical variables among groups and the Mann Whitney *U* test to detect differences between the distributions among groups.

RESULTS

There were a total of 539 respondents, with demographic characteristics shown in Table 2. For the purpose of this study, we excluded responses from medical students and attending physicians, thus analyzing a total of 490 responses. There was an even distribution of residents and fellows across all levels of training. Of the fellows, pediatric critical care medicine and pediatric emergency medicine fellows accounted for the majority of respondents. Trainees' clinical decisions in each of the four hypothetical scenarios are detailed in Table 3. Table 4 illustrates different choices selected by experts compared to non-experts for all the four scenarios.

In scenario 1, 85% of respondents chose to continue resuscitation of shock, with an even split of respondents choosing fluid (38%) or vasoactive (47%). Most people cited the ACCM/PALS guideline cutoff of 60 mL/kg for fluid administration as the rationale for choosing vasoactives over fluid. Of the remaining 15%, 9% of respondents required additional data before determining course of action - including mental status, urine output, signs of fluid overload and ultrasound measures of fluid status. Six percent of respondents chose to halt resuscitation. The most common reason cited for stopping resuscitation was to give antipyretic and evaluate heart rate response as tachycardia could be due to presence of fever. Other reasons were "normal blood pressure", giving Ⅳ fluids at higher than maintenance rate to treat shock and avoidance of pulmonary edema. Thirty-six percent of respondents said they had only slight confidence in their decision. There was no correlation of low confidence level with primary decision taken.

For scenario 2, 80% of respondents chose to continue resuscitation of shock, with 20% choosing fluid and 60% choosing vasoactives. The most common reason cited for not continuing resuscitation was interpretation of CVP as normal. Other reasons included awaiting chest X-ray to evaluate for pulmonary edema, echocardiogram for assessing cardiac function, and assessing adequacy of urine output. In this case, 65% of respondents were only slightly confident of their decision. Of respondents who chose to halt resuscitation or obtain additional data first, 76% (70 out of 92) expressed low confidence, compared to those who chose to give either fluid or vasoactive, where 60% expressed low confidence.

For scenario 3, 39% of total respondents choose to give additional fluid, 15% would give a vasoactive, and 46% elect to not continue resuscitation. The most common reason by far for not continuing resuscitation is the known cardiac comorbidity, with several trainees requiring an echocardiogram to evaluate for cardiac function first. The next most common factor cited is the presence of fever, and several respondents want to reevaluate the degree of tachycardia after fever has subsided. Other reasons for slowing or halting resuscitation include obtaining a chest X-ray, cultures and antibiotics, and transfer to the pediatric intensive care unit. Sixty-four percent of all respondents express poor confidence in decision. In this case, prevalence of low confidence level is the same - at 64% in all respondents regardless of whether or not they pursue to continue resuscitation or delay/halt resuscitation.

For the patient in scenario 4, 43% of respondents elected to not perform any additional intervention, 29% chose to give a fluid bolus and 20% elected to increase vasoactive support. By far the most common reason for administration of fluid or increasing vasoactive dose was the CVP value. A majority of respondents (61%) expressed low confidence in their decision.

DISCUSSION

Early identification and rapid reversal of shock has been well documented to improve outcomes. We surveyed pediatric residents and fellows to assess how they made decisions regarding treatment of shock, and uncovered some commonly prevalent biases and errors in management.

The first scenario describes a 5-year old who is clearly presenting in shock, with end-organ dysfunction manifested by altered mental status. She has already received the initial 60 mL/kg of fluid. Per the ACCM guidelines[6], fluid resuscitation should be continued until signs of pulmonary overload occur or shock is reversed, defined by achieving threshold heart rate (HR) and MAP-CVP values, which were not yet achieved in this girl. In our experience, the initial 60 mL/kg is given automatically, and then there is some complacency while the patient awaits transfer to the intensive care unit (ICU). This can be thought of in terms of "premature closure" and "representativeness", where a diagnostic category is assigned to the patient and clinical response after 60 mL/kg of fluid is taken for granted, as this amount would suffice for most patients. Ideally, central

Table 1 Clinical case scenarios and outcomes studied

Case	Scenario description	Clinical questions	Key clinical features	Expected interventions	Outcomes studied
1	A 5 yr-old girl is brought into the emergency department with fever, diarrhea and vomiting. She is drowsy and does not answer questions appropriately. Her vitals are as follows: Temp 38.4 ℃, HR 168/min, RR 36/min, BP 90/45 (MAP 60) mmHg. She seems dehydrated with dry mucous membranes, is warm, flushed and has flash capillary refill. You diagnose septic shock and after getting two good Ⅳ lines for access, begin rapid fluid administration. You give her 60 mL/kg crystalloids over a period of 60 min, and one dose of antibiotics. At the end of this time, her vitals are as follows: Temp 38.4 ℃, HR 165/min, RR 32/min, BP 96/40 (MAP 59) mmHg, capillary refill unchanged. What would be your next plan of action?	What would be your next plan of action (1) Do nothing at this point; (2) give an additional 20 mL/kg fluid bolus; (3) start a vasoactive medication; (4) need additional data to decide- please specify; (5) Other What factors were used for decision making? HR/BP/Cap refill/ Response to fluid/ other (specify) How confident are you in decision on a scale of 0 (not confident at all) to 4 (sure of decision)	Severe shock with altered mental status Ongoing shock with HR and MAP not at threshold levels per ACCM-PALS guidelines	Continue resuscitation with either fluid or vasoactive administration evaluate lactate, mixed venous saturations	Rationale in choosing fluid *vs* vasoactive, or vice versa Rationale for withholding resuscitation Confidence level in decision-making
2	You are caring for a 4 yr old in the PICU with severe septic shock due to lobar pneumonia. His first night of admission he received 60 mL/kg of crystalloids and 20 mL/kg of 5% albumin. When you see him this morning, he is barely arousable and has a cap refill time of 5 s. You insert an internal jugular line and a radial arterial line. His vitals at this time are as follows: Temp 37.5 ℃, HR 152/min, RR 35/min, BP 100/45 (MAP 63) mmHg. His CVP is 8 mmHg. You obtain a blood gas from the A-line, and his lactate is 4.5 mmol/L. You decide to intubate to reduce oxygen consumption related to work of breathing. Despite adequate sedation, he persists to have tachycardia; vitals after intubation are as follows: Temp 37.5 ℃, HR 168/min, BP 110/40 (MAP 63) mmHg, CVP 10 mmHg, cap refill time 5 s. You immediately have to escalate to very high ventilator settings with pressure control of 34 and PEEP of 10 to achieve acceptable oxygenation and ventilation. What would your next intervention be?	What would be your next plan of action (1) Do nothing at this point; (2) give an additional 20 mL/kg fluid bolus; (3) start a vasoactive medication; (4) need additional data to decide- please specify; (5) Other What factors were used for decision making? HR/BP/CVP/Cap refill/Response to fluid/other (specify) How confident are you in decision on a scale of 0 (not confident at all) to 4 (sure of decision)	Worsening hemodynamics after initiation of positive pressure ventilation	Resuscitate shock with fluid or vasoactives	Recognition of decrease in preload caused by initiating of positive pressure ventilation Interpretation of CVP in conjunction with higher intrathoracic pressures
3	While rotating through the Hematology Oncology unit, you are called to the bedside of a 12-yr old receiving maintenance chemotherapy for AML. She has developed a temperature of 39.3 ℃. On exam she has a HR of 160/min, RR 32/min, BP 110/40 (MAP 63) mmHg, and cap refill of 3 s. She is known to have anthracycline-induced cardiomyopathy. You palpate her abdomen and notice that her liver is 3-4 cm, similar to earlier, she has no murmur or gallop, and a CVP transduced through her broviac is 6 mmHg. In the last 4 h, her urine output has reduced from 1.5 mL/kg·h to 0.3 mL/kg·h. You decide to cautiously give her a 10 mL/kg fluid bolus over half an hour to see the response. At the end of the bolus, her HR is now 154/min, BP is 106/46 (MAP 66) mmHg, CVP has increased to 8 mmHg. What would your next step be?	What would be your next plan of action (1) Do nothing at this point; (2) give an additional fluid bolus; (3) start a vasoactive medication; (4) need additional data to decide- please specify; (5) Other What factors were used for decision making? HR/BP/Cap refill/ Response to fluid/ other (specify) How confident are you in decision on a scale of 0 (not confident at all) to 4 (sure of decision)	Known cardiomyopathy with onset of shock Low CVP and absence of hepatomegaly Good response to fluid bolus	Continue fluid resuscitation	Rationale for halting or slowing resuscitation

4	You are caring for a 6 yr old girl admitted to the PICU after anaphylactic shock from a bee sting. She has required a lot of fluid in the 4 h since admission-a total of 60 mL/kg, and is currently on dopamine at 7 mg/kg per minute. She has a urine output of 1 mL/kg per hour. She is on 2 L NC, and her vitals are as follows: Temp 36.8 ℃, HR 115/min, RR 16/min, BP 95/65 (MAP 75) mmHg, with flushed extremities and cap refill of 2 s. You insert an internal jugular line and when you transduce it, you get a CVP of 3 mmHg. What would you do next?	What would be your next plan of action (1) Do nothing- continue maintenance fluids; (2) give an additional 20 mL/kg fluid bolus; (3) increase vasoactive medication; (4) need additional data to decide- please specify; (5) other What factors were used for decision making? HR/BP/Cap refill/ Response to fluid/ other (specify) How confident are you in decision on a scale of 0 (not confident at all) to 4 (sure of decision)	Vital signs not suggestive of shock Incidentally transduced CVP level of 3 mmHg	Do not continue any further resuscitation	Percentage continuing fluid resuscitation based on isolated CVP value

ACCM: American college of critical care medicine; PALS: Pediatric advanced life support; MAP: Mean arterial pressure; CVP: Central venous pressure.

Table 2 Demographics of respondents

Demographics of respondents	*n* (%)
Total respondents	539 (100)
Medical students	37 (7)
Residents	393 (73)
Fellows	97 (18)
Attending physicians	12 (2)
Level of training- residents	367[1] (100)
PGY-1	120 (33)
PGY-2	110 (30)
PGY-3	121 (33)
PGY-4	16 (4)
No response	26
Level of training- fellows	901 (100)
PGY-4	25 (28)
PGY-5	32 (35)
PGY-6	29 (32)
PGY-7	4 (4)
No response	7
Pediatric fellows' specialty (97)	
Pediatric critical care medicine 25 (26)	
Pediatric emergency medicine 22 (23)	
Neonatology 14 (14)	
Pediatric hospital medicine 5 (5)	
Pediatric cardiology 4 (4)	
Other 27 (28)	

[1]Total number of respondents to this question from all survey takers.

venous access should be obtained and vasoactive medications made available to be started immediately if needed, while assessment of shock should proceed with the same urgency as at initial presentation, especially in the presence of ongoing losses. We found that most respondents were appropriately aggressive, opting to continue either fluid or vasoactive. While most respondents explicitly cited that they were basing their decision on ACCM guidelines, most also interpreted the blood pressure as normal, although the MAP was below the threshold recommended in the ACCM guidelines. It would be interesting to study how prevalent is this departure from the guidelines while treating shock, and whether the thresholds recommended by the ACCM are actually achieved in practice.

Scenario 2 dealt with a more complex situation where positive pressure ventilation had just been initiated. While advanced cardiopulmonary interactions are beyond the scope of general pediatric training, the ACCM guidelines mention that fluid loading might be necessary with the initiation of positive pressure ventilation due to a resultant reduction in the preload. The scenario describes florid shock with altered mental status, tachycardia despite adequate sedation, a heart rate of 168 and a diastolic blood pressure of 40 mmHg in a 4-year old child. The CVP of 10 mmHg in the face of very high intrathoracic pressures does not reflect in any way on intravascular volume status. The most common reason for inadequate resuscitation was the CVP value. Interestingly, a low confidence level was correlated with inaction in this scenario. This can be seen as a form of "omission bias"-one of the commonest biases in clinical medicine, where events occurring through the natural progression of a disease are more acceptable than those that may be directly attributed to the action of the physician.

In the third scenario, though the patient is known to have chemotherapy-induced cardiomyopathy, her liver size is not enlarged from baseline, CVP is low, and heart rate improves with an initial 10 mL/kg bolus. The probability that fluid administration will be harmful given these clinical attributes is inflated, and the far more likely possibility that there is ongoing shock in an immunocompromised host is minimized. This is a form of "base rate neglect"-clinicians conflate probabilities to rule out the worst case scenario.

Table 3 Responses to clinical scenarios

Scenario	Fluid bolus	Vasoactive	No further intervention/ need more data/other	Factors cited as important for decision-making	Percentage with low confidence
1-septic shock s/p 60 mL/kg fluid	38%	47%	15%	Capillary refill, response to fluid	36%
2-hemodynamic instability s/p initiation of positive pressure ventilation	20%	60%	20%	CVP, lactate	65%
3-shock with comorbid cardiomyopathy	39%	15%	46%	HR, BP	64%
4-anaphylaxis with resolved shock	29%	20%	51%	CVP	61%

s/p: Status post; CVP: Central venous pressure; HR: Heart rate; BP: Blood pressure.

Table 4 Preferences of non-experts *vs* experts

Scenario	Role	Bolus (% of total)	Vasoactive (% of total)	Other (% of total)	*P* value
1-septic shock with ongoing losses	Non-experts[1] (n = 438)	40	47	13	0.02
	Experts[1] (n = 52)	25	50	25	
2-worsening hemodynamics after intubation	Non-experts (n = 438)	21	59	20	0.08
	Experts (n = 52)	11	73	16	
3-shock in a child known to have cardiomyopathy	Non-experts (n = 438)	39	15	46	0.77
	Experts (n = 52)	42	17	41	
4-recovering anaphylactic shock with low CVP	Non-experts (n = 438)	29	21	50	0.01
	Experts (n = 52)	25	8	67	

[1]Experts: Fellows in pediatric critical care, pediatric emergency medicine, and pediatric hospital medicine; Non-experts: All other respondents.

In scenario 4 - the patient has required a fair amount of fluid and vasopressor, but has an adequate urine output and normal vitals. Again in this case, CVP of 3 mmHg takes precedence in decision-making and half of all respondents elect to give additional fluid or increase vasoactives.

We uncovered some common themes across the scenarios. The presence of fever can act as a confounding factor in the attribution of tachycardia to the shock state. This leads to delay in treatment for shock while treating with antipyretics and awaiting fever to subside before assessing degree of tachycardia. It is important to emphasize to trainees that while awaiting antipyretics to take effect, it is vital to continue resuscitative measures for shock. Although several clinical studies have widely disproven the utility of CVP both as a marker of intravascular volume state as well as an indicator of fluid responsiveness[10,11], CVP is still widely used in decision-making regarding fluid status, often taking primacy over other signs. This approach is not only not useful, it can be potentially harmful as we have shown, where the contribution of factors such as intrathoracic pressure and diastolic function to CVP is not considered, and a normal CVP value leads to a premature halt to resuscitation. Conversely, a CVP of 3 mmHg is normal in a spontaneously breathing child with normal cardiac function and does not indicate hypovolemia[12]. Interpretation of a given CVP value should take into account these aforementioned factors, with recent expert opinion suggesting that extreme values of CVP may still be useful to guide resuscitation[13]. Though some respondents mentioned using ultrasound measures to ascertain for fluid status, markers of fluid responsiveness such as respiratory variation in peak aortic velocity require the absence of spontaneous breathing in a mechanically ventilated patient, as well as some expertise to obtain[14]. Furthermore, although echocardiography might give a general idea as to cardiac function, it does not yield any information on systemic vascular resistance or intravascular volume. Myocardial depression often coexists with septic shock[15], yet these children need to be resuscitated with either fluid or vasopressors, and clinical exam for response to fluid, hepatomegaly and rales is usually the only tool available at bedside. As such, it is not appropriate to await results of echocardiographic imaging to make decisions on fluid resuscitation. Experts were more likely than non-experts to prefer vasoactive medication to fluid in all instances except for scenario 4, and were uniformly more confident.

Our study has several limitations. Answering questions on a survey does not replicate the experience of examining a patient and assessing the evolution of disease in real time. In practice, each patient is immeasurably complex and there are multiple sources of clinical input - both conscious and subconscious. For sake of keeping the question stem at a reasonable length, we had to handpick what we considered the most relevant information. There is also the inevitable introduction of the Hawthorne effect here-respondents are aware that they are completing a survey on fluid management practices and this knowledge might further add to the

inaccuracy of survey responses compared to actual decisions made. Thus the survey-based methodology is far less rigorous than conducting a prospective study and debriefing pediatric trainees in real time.

To conclude, while pediatric trainees are most confident when following ACCM guidelines to treat shock, they face a high degree of decisional conflict and lack of confidence when encountering alternative etiologies and comorbidities. Educational interventions targeting the biases outlined in our study could be of benefit.

ARTICLE HIGHLIGHTS

Research background

Pediatric trainees are often the first responders at the bedside for evaluation and ongoing management of children presenting with various shock states, yet there is little data on how they navigate through these decisions or how confident they feel in making these decisions. We conducted a survey of pediatric trainees all over the United States. Our study is the first study to survey in the literature studying fluid administration practices of trainees.

Research motivation

The motivation for performing this research was to uncover common situations where pediatric trainees faced a significant decisional conflict when treating shock. We also aimed to uncover some common situations where under-resuscitation was common and to highlight cognitive biases and fallacies of trainees while assessing and treating children with shock.

Research objectives

One of the study objectives was to assess level of adherence and confidence level with American College of Critical Care Medicine (ACCM) guidelines which are universally followed in the United States for treatment of septic shock. Additionally, we wanted to assess degree of reliance on central venous pressure, resuscitation in children with ongoing cardiac comorbidity. We also sought to discover if there were significant differences in treatment practices of more advanced level trainees such as pediatric critical care, hospital medicine and emergency medicine fellows. All these objectives were realized, and can help in training and supporting pediatric residents for management of shock.

Research methods

We conducted a nationwide survey of all pediatric trainees in the United States. This included residents at all levels of training, and fellows training in one of the subspecialties of pediatrics. The survey was voluntary and anonymous. Statistics were primarily descriptive, and SPSS was used for performing additional statistical testing.

Research results

We found that pediatric trainees across all levels of training faced a high degree of uncertainty and lack of confidence while they were making decisions regarding fluid administration in children presenting with shock. ACCM guidelines are frequently cited, yet blood pressure goals cited in the ACCM guidelines are often not met, nor is a suboptimal blood pressure recognized. Children with coexisting cardiac comorbidities may be prone to severe under-resuscitation for fear of cardiac failure causing pulmonary edema. Fever is an important confounding factor often delaying recognition of shock. This study sheds light on these important observations, and further prospective observational studies are warranted which study decision-making of trainees.

Research conclusions

This study is the first study on how trainees in pediatrics make decisions for treatment of shock. It is vital that shock be recognized and treated rapidly, yet there are no studies looking at how confident trainees feel in their judgment. This study points to a very low level of confidence when treating shock, and some common situations which should be highlighted to trainees while caring for patients or in simulated scenarios.

Research perspectives

Pediatric trainees should be supported adequately and provided focused teaching related to treatment of shock states in children. Children with malignancy and cardiac comorbidity who present with septic shock are a uniquely vulnerable population prone to under-resuscitation and should be managed by expert physicians. Central venous pressure should be interpreted with caution and not used in isolation without entire clinical picture.

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