Barriers affecting compliance with the implementation of early goal directed therapy in the emergency department

2013

Ivan Castro
University of Central Florida

BARRIERS AFFECTING COMPLIANCE WITH THE IMPLEMENTATION OF EARLY GOAL DIRECTED THERAPY IN THE EMERGENCY DEPARTMENT

by

IVAN ENRIQUE CASTRO

A thesis submitted in partial fulfillment of the requirements
for the Honors in the Major Program in Nursing
in the College of Nursing
and in The Burnett Honors College
at the University of Central Florida
Orlando, Florida

Spring Term 2013

Thesis Chair: Dr. Christopher Blackwell

ABSTRACT

Early Goal Directed Therapy (EGDT) has been thoroughly researched and clinically supported to be effective at lowering morbidity and mortality associated with severe sepsis and septic shock. Due to the strengths of its efficacy, it has been integrated as an essential component of the Surviving Sepsis Campaign. However, very few studies have explored the barriers that affect compliance of the protocol in actual practice. The purpose of this study was to synthesize current research findings regarding nursing barriers associated with EGDT. This research was limited to studies performed in the United States between 2003-2012, with patients at least 18 years old, and with data obtained from studies conducted within emergency departments (EDs) only. These findings may serve to help increase the compliance rate with the protocol among nurses in the ED. Findings indicated that compliance rates were mostly affected by two major barriers: 1) Lack of knowledge regarding the presentation and management of sepsis and septic shock, and 2)Lack of resources in the ED to perform the protocol to its full potential. Limitations of the review noted were that most research studies used were in major academic hospitals which limited the generalizability of the findings to other hospital settings. Nursing education should emphasize early recognition and aggressive treatment of sepsis. Future research should focus on addressing the most efficient ways to educate nurses on sepsis presentation and management and the ways these can be implemented in practice.

DEDICATIONS

First, to my mom, Susana, who has supported through all my endeavors. I could have never made it this far without you.

Secondly, to all my family back in Port Orange, especially Tita. You all stood by me when things were looking grim and hopeless and helped me through some rough times. I will never be able to pay you back for what you have done for us.

Last but not least, to my very close friends: Spencer, Brie, Monica, and Jamie. Without you guys to keep me sane and to remind me of deadlines, I would have never made it through.

ACKNOWLEDGEMENTS

I would like to thank Dr. Christopher Blackwell for guiding and putting up with me though this entire process. Without you this project would not have been possible.

I would also like to thank Dr. Stephen Heglund for helping me understand what research was all about. Without your original enthusiasm and positive energy I would have never committed to taking on this project.

I would finally like to thank Dr. Reid Oetjen for providing an outside perspective into this particular issue.

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INTRODUCTION

Sepsis and septicemia are often interchangeably used terms that describe an infection of the bloodstream that can rapidly become fatal if not treated aggressively (Hall, Williams, DeFrances, & Golosiskiy, 2011). According to the Center for Disease Control and Prevention (CDC), $14.6 billion were spent in 2008 on the hospitalization of patients for sepsis. The inflation adjusted aggregate cost to treat septic patients has increased annually by 11.9% (Hall et al.). Despite the large number of clinical resources dedicated to the treatment of septic patients, the disease is the 10th leading cause of death in the United States and is associated with more discharges to rehabilitation and long-term care facilities than any other condition (Hall et al.). Severe sepsis and septic shock carry a much higher mortality rate, with 30% of patients dying from the condition (Focht, Jones, & Lowe, 2009). Sepsis has traditionally been differentiated into three separate categories: sepsis, severe sepsis, and septic shock.

The clinical definition for sepsis is a suspected or documented infection that presents itself with two or more criteria of Systemic Inflammatory Response Syndrome (SIRS) (Robson, Newell, & Beavis, 2005). These criteria include hyperthermia (above 38°C or 100.4°F) or hypothermia (below 36°C or 96.8°F), tachycardia (heart rate above 90 beats per minute), tachypnea (more than 20 respirations per minute), and leukocytosis (above 12,000 white cells per mL of blood) or leukopenia (below 4,000 white cells per mL of blood) (Dellinger et al., 2013). SIRS may be caused by trauma, myocardial infarction, or burns and have no particular

connection with sepsis. However, the clinician must take both the infective agent and SIRS into account when making a diagnosis of sepsis.

In order for a clinical diagnosis of severe sepsis to be made, the patient must meet the criteria for sepsis and present with signs of organ dysfunction and/or hypotension (systolic blood pressure below 90 mmHg or a mean arterial pressure below 60 mmHg) (Robson et al., 2005). Any organ may be affected and signs will vary according to the effected organ. For the disease to progress into septic shock, the patient must have a blood lactate concentration greater than 4 mmol/L and/or hypotension that persists after an initial infusion of up to 2 liters of normal saline (Dellinger et al., 2008). However, septic shock can present clinically with a normal blood pressure. This is called normotensive shock, occult shock, or cryptic shock depending on the author (Mikkelson et al., 2010). Patients who present clinically with severe sepsis and an elevated lactate level but are normotensive should be resuscitated with EGDT as these patients have been shown to have a similar mortality rate than septic patients that present with hypotension (Mikkelson et al.).

Traditionally, the treatment of severe sepsis and septic shock was performed in an intensive care unit (ICU), because this clinical environment had both the equipment and supply resources as well as the appropriately educated and skilled staff to treat these types of patients (Giuliano, Lecardo, & Staul, 2011). The consequences of crucial time required for patients to wait for transfer into the ICU was first documented by Emanuel Rivers, a board certified emergency medicine physician. He emphasized the importance of the “golden hour” when patients begin to show signs of global tissue hypoxia, to when organ dysfunction and death

occurred (Rivers et al., 2011). As a result, he proposed and experimented with Early Goal-Directed Therapy (EGDT) in the ED, focusing on the stabilization and manipulation of cardiac preload, afterload, and contractility (Rivers et al.). His study showed that early aggressive therapy performed in the ED not only decreased the mortality rate by 16% but also decreased the medical resources used per patient.

The EGDT resuscitation protocol (Appendix A) has five major goals: 1) administering intravenous (IV) antibiotics within the first 3 hours of admission into the ED, 2) the stabilization of central venous pressure (CVP) between 8-12 mmHg, 3) maintaining mean arterial pressure (MAP) above 65 mmHg, 4) maintaining urine output above 0.5 ml/kg/hr, and 5) maintaining central venous oxygen saturation above 70% (Dellinger et al., 2008). Achieving and maintaining these goals in the first six hours of diagnosis of sepsis requires a well-educated and well-staffed health care team as intubation, colloid or crystalloid administration, blood transfusions, central venous catheter (CVC) insertion, arterial line insertion, and vassopressors administration among other tasks may need to be performed (Dellinger et al.).

Since Rivers' et al. (2001) original research, other clinicians have experimented with EGDT in their respective institutions and have shown that the original results can be replicated to other facilities and the protocols can be performed in most hospitals (Nguyen et al., 2007; Crowe, Mistry, Rzechula, & Kulstad, 2010; O'Neill, Morales, & Jule, 2012). Despite the supportive findings of most studies, only 10% of emergency medicine residency programs are using EGDT (Crowe et al., 2010).

Surviving Sepsis Campaign

The Surviving Sepsis Campaign (SSC) compiled input from 68 international experts who have examined the research data available to provide recommendations to clinicians in order decrease the morbidity and mortality associated with sepsis (Dellinger et al., 2013). The latest review of the literature and recommendations was published in 2013 using data as recent as 2012. These guidelines provide a wide range of recommendations on how to treat septic patients. The main recommendation of the campaign is early resuscitation of the patient and follows many of the guidelines described in the original publication by Rivers et al. (2001). It adds a time frame for the administration of antibiotics (within three hours) upon diagnosis of severe sepsis and determines that the patients should be resuscitated within 6 hours of a diagnosis of severe sepsis or septic shock (Dellinger et al.). The recommendation to obtain blood cultures before antibiotics are administered is also supported (Dellinger et al.). Both of these interventions further contribute to the guidelines already enumerated in EGDT. SSC also contains many recommendations for the care of septic patients in the ICU, such as ventilator settings and continued care post admission (Dellinger et al.).

Pathophysiology of sepsis

Sepsis is the end result of a complex interaction between pathogen and host that leads to an inappropriate response by the host to the offending organism (Nduka & Parrillo, 2009). As a result, the effects perceived in all forms of sepsis can be categorized into organism related components and host related components.

Organism related

All sepsis begins with an offending pathogen. This pathogen may be either bacterial, viral or fungal. The proliferation of the pathogen and consequential destruction of host cells leads to an immunological response by the host. In most cases, this response will conclude with the eradication of the pathogen and a return to homeostasis. In sepsis, due to either the virulence of the pathogen or the immunocompromised state of the host, the original immune response is not enough to destroy the invading organism. This allows quorum-sensing systems (QSS) in bacteria to coordinate gene activation among a colony and increase production of virulence factors (Nduka & Parrillo, 2009). The QSS's in bacteria allow a global control system to regulate virulence gene expression in a colony in order to prevent excessive virulence factors when colony population is low. This would prevent early immunological detection of weaker colonies. Global control with QSS allows for fast proliferation and swift establishment of infection. Recent research (Nduka & Parrillo) has also suggested that QSS's in bacteria can bind host inflammatory chemicals, such as interferon-γ, which suggests that virulent gene expression could be host-dependent, allowing bacteria to assess when the host would be most susceptible for infection.

Host related

Once a pathogen has infected the host, the pathogen-associated molecular patterns (PAMPs) in the infecting organism combined with intracellular proteins released from injured host cells, known as damage-associated molecular patterns (DAMPs), are detected by pattern recognition receptors (PRRs), specifically toll like receptors (TLRs) in cells of the innate immune

system (Nduka & Parrillo, 2009). Some examples of the PAMPs detected by TLRs are lipopolysaccharides (LPS), expressed by virulent Gram negative bacteria, flagellin, present in bacterial flagellum, and bacterial DNA (Anas, Wiersinga, de Vos, & van der Poll, 2010). Fibrinogen and hyaluronic acid are examples of DAMPs that interact with TLRs to produce an innate immune response (Anas et al., 2010). Once the innate immune system detects the presence of host cell injury and foreign proteins, they release a series of chemicals such as tumor necrosis factor alpha (TNF-α) and interleukin-1 (IL-1), intended to induce chemotaxis of phagocytes to the area of injury. The activation of an innate immune response reaction leads to the early SIRS symptoms associated with sepsis (Kortgen, Hofmann, & Bauer, 2006).

The extended pathogen induced damage associated with sepsis causes an overwhelming activation of TLRs by DAMPs leading to an intensified innate immune response. Although the innate immune system is designed to prevent and or control the spread of infection, over excitation of this system can be very detrimental to the host (Anas et al., 2010). The negative effects of over excitation have been shown in TLR deficient mice. These mice have immunity to LPS (a PAMP) induced septic shock but show predisposition to Gram negative bacterial infections (Anas et al.).

The host's immune system will attempt to limit the inflammatory response through the use of cholinergic molecules, primarily α-7 cholinergic receptor agonist, one of which is acetylcholine. This parasympathetic response, mediated by the vagus nerve, inhibits the production of cytokines in macrophages leading to a decrease in inflammation and a return to homeostasis. However, for reasons not understood, hosts susceptible to sepsis will not

demonstrate a strong enough cholinergic response to deter the immune system's inflammatory response. This will consequentially lead to septic shock (Nduka & Parrillo, 2009).

In sepsis, the overstimulation of the innate nervous system leads to an increase in the amount and duration that very powerful pro-inflammatory cytokines spend in systemic circulation. This high concentration and prolonged exposure to the cytokine cascade system poses harmful biological effects to the host such as cytokine induced cellular apoptosis, micro and macrocirculatory failure which leads to hypoxia induced necrosis. The combination of the two, causes multiple organ dysfunction syndrome (Kortgen et al., 2006).

Survival of sepsis often leaves the host in a state of immunoparalysis (Anas et al, 2010). This immunological "exhaustion" caused by the hyperactivity of the immune system leaves the host immunocompromised and prone to nosocomial infections once the acute phase of sepsis is over.

Coagulopathy

Almost all patients with severe sepsis have some form of coagulopathy. The elevated serum levels of cytokines leads to a dysfunction coagulation system in the host. Elevated levels of TNF-α induce endothelial cells and subendothelial cells in the vasculature to produce tissue factor (TF) (Nduka & Parrillo, 2009). The production of TF to start the coagulation cascade paired with the consequential activation of clotting factors leads to the over production of thrombin and the conversion of fibrinogen into fibrin. The inhibition of production of protein C, a natural inhibitor of thrombin formation, and tissue plasminogen activator (tPA), a protein mediator of fibrinolysis, by cytokines and plasminogen activator inhibitor-1 (PAI-1) respectively,

further impairs coagulation (Ely & Bernard, 2005). Normally, anti-inflammatory mediators and coagulation inhibitors would stabilize endothelial response to inflammation or trauma, and bring the system back into homeostasis. In sepsis, however, the overwhelming response to inflammatory molecules coupled with the deficient concentrations of modulators, such as protein C and antithrombin III, fails to prevent further endothelial damage. This unregulated inflammation and coagulation cascade can lead to disseminated intravascular coagulation (DIC), causing further hypoxic damage to major organs and, eventually, death (Nduka & Parrillo).

Epidemiology

Despite advancements in treatment and generous allocations of resources, sepsis remains the 10th leading cause of death in the United States (Hall et al., 2011). Between 2000 and 2008, rates of sepsis have more than doubled, from 11.6 hospitalizations per 10,000 population to 24.0 (Hall et al., 2011). At nearly 65%, patients over 65 years of age make the majority of those diagnosed with sepsis (Hall et al.). The rate of sepsis for people over the age of 85 years of age was more than 30 times that of those under the age of 65 (Hall et al.). There are no statistically significant rate discrepancies between males and females (Hall et al.). Patients hospitalized for sepsis had an average length of stay that was 75% longer than those hospitalized for other conditions, with those patients under 65 doubling the average length of stay (Hall et al.). In-hospital deaths were more than 8 times more likely for sepsis than with patients with other diagnoses. In fact, only 2% of hospitalizations in 2008 were for sepsis, yet this caused 17% of the in-hospital deaths (Hall et al.). Those patients who survived the original

sepsis diagnosis were three times more likely to need long term care in a skilled facility than those with other diagnoses (Hall et al.).

Severe sepsis accounts for over 500,000 ED visits annually, with an average length of stay in the ED of 4.7 hours (Wang, Shapiro, Angus, & Yealy, 2007). Of those visits, over half arrived by ambulance (Wang et al., 2007). The national cost of treating sepsis in the United States has risen, with the national estimate in 2008 being $14.6 billion (Hall et al., 2011).

PROBLEM

Despite best efforts to improve treatment for sepsis, it still remains the 10th leading cause of death in the United States and accounts for over 500,000 ED visits each year (Crowe et al., 2010). How health care providers assess and treat sepsis can potentially determine the fate of thousands of patients each year. EGDT provides a template to standardize the care of septic patients as soon as they present to the ED, instead of waiting for admission to an ICU.

While various studies have shown that EGDT has the ability to reduce the mortality rate of severe sepsis by up to 16%, there are many barriers that prevent it from being implemented as intended (Crowe et al., 2010). Once a comprehensive and thorough review of the literature has been conducted and the weaknesses in implementation have been identified, a plan can be conceived to address those shortcomings and improve mortality rates while decreasing the use of medical resources per patient. This would not only improve the health of patients but it would improve the efficiency of the health care system as well.

PURPOSE

The purpose of this study was to review the existing research on EGDT and factors that facilitate or prevent nurses from properly implementing such therapies in the ED setting. In addition to the review of the major findings of these data, suggestions were provided as to which nursing barriers are largely attributed to the inadequate implementation of EGDT and what strategies could be implemented to improve nursing adherence and patient care.

METHOD

A review of the existing literature regarding EGDT in adult patients and the nursing barriers that prevent its proper implementation was performed. Information was collected from databases including the Cumulative Index to Nursing and Allied Health Literature, the Cochrane Review and MEDLINE via electronic and printed access. Terms used to query the databases were: “Early Goal Directed Therapy” OR “EGDT compliance” OR “EGDT nurs*” OR “EGDT protocol” OR “EGDT” OR “Early Goal Directed Therapy compliance.”. The inclusion criteria were patients with sepsis, research conducted in EDs, research conducted after 2003 and research published in English. The exclusion criteria were research studies with patients younger than 18 years of age, research studies conducted outside of the ED (eg. ICU, Med-Surg, etc.), research conducted before 2003, and research studies performed outside of the United States of America. The search yielded 72 articles and 7 of them were deemed relevant to this study because they met the inclusion and exclusion criteria.

FINDINGS

The search yielded 72 articles. Of those, only 7 were deemed relevant to this study once the inclusion/exclusion criteria were applied.

The first article was published by Micek et al. (2006) and was a prospective observational cohort of 120 patients in a large academic medical center. The study was done to evaluate a standardized hospital order set for septic shock in the ED. Staff was educated on sepsis diagnosis and protocol before the start of study. The study required extra time, resources, and equipment to implement the protocol.

Carlbom & Rubenfeld (2007) was a national quantitative and qualitative phone survey with 24 physician directors and 40 nursing managers representing 53 ED's.

Nguyen et al. (2007) was a two year observational perspective cohort of 330 patients in an academic tertiary medical center with 65,000 ED visits a year. The study was done to see if education and clinician feedback could increase compliance with EGDT. No additional staff was recruited, but new equipment was bought to measure central venous oxygen saturation.

Mikkelsen et al. (2010) was a retrospective cohort study of 340 EGDT-eligible patients admitted through the University of Pennsylvania ED. A Severe Sepsis Consultation Service (SSCS) was put in place in order to assist with diagnosis and management of sepsis. The SSCS functioned much like a sepsis "code team" as they helped in managing the care of septic patients, alleviating the time and resource demand placed on the existing ED staff. No additional education was offered to the ED staff, including nurses.

Crowe et al. (2010) was an observational study of prospectively identified patients treated with EGDT compared with retrospectively obtained data on patients treated before protocol implementation. Compliance of EGDT protocol was studied in 216 patients in a Tertiary level hospital with more than 85,000 ED visits yearly. No additional staff was recruited, but education on sepsis and its management with EGDT was provided to physician and nurses.

Burney et al. (2012) was an online survey offered to nurses and physicians (n=101) in an ED of a major urban academic medical center. Questionnaire was designed to assess perceived barriers to implementation of goal directed therapy.

O'Neill et al. (2012) was a non-concurrent cohort study of 98 adult patients entered into an EGDT protocol at a single community hospital over 9 months. The study was intended to measure compliance with the protocol. The community hospital ED where this study was performed had an average of 65,000 visits per year. No additional staff was recruited, but education was provided to physicians and nurses in the ED.

Upon review of all 7 studies that met the inclusion and exclusion criteria, two major barriers were extrapolated: 1) lack of education of the nursing and physician staff in the ED regarding sepsis presentation and management, and 2) lack of resources to comply with EGDT guidelines according to the Surviving Sepsis Campaign.

Lack of education of the nursing and physician staff regarding the presentation of sepsis can be clearly identified in the data. Only two of the five patient-based studies provided statistics as to how many EGDT eligible patients actually received the protocol. Both of these studies indicated that 42% of patients potentially meeting criteria for treatment with RGDT

protocol were not captured. This indicates that almost half of all septic patients in those two studies were excluded from early resuscitation because they were not thought to be seriously ill enough to require resuscitation, a diagnosis of severe sepsis was never made, or they progressively declined after first assessment and were not treated on time. Issues were also found in successful completion of the EGDT protocol. Mikkelsen et al. (2010) showed that just 57% of the patients that were started on the EGDT protocol actually completed it, with 43% not provided with some level of care dictated by the protocol, such as central venous pressure monitoring or central venous oxygen saturation monitoring. This finding is corroborated by both of the surveys, as they show that at least 38% of the nurses surveyed believed that lack of recognition of early signs of sepsis was a major barrier to implementing EGDT in their ED.

Nguyen et al. (2007) provided evidence to suggest that with two years of continuous staff education stressing the importance of resuscitation through EGDT and meaningful staff feedback, identification of EGDT eligible patients can increase from 51% to 83% without a need to hire new staff. Supporting this finding, Mikkelsen et al. (2010) showed that when clinicians activated the Severe Sepsis Consultation Service (SSCS), a guiding body of experts intended to provide advice regarding diagnosis and management of EGDT eligible patients, 71.2% of eligible patients had the EGDT protocol initiated. When providers failed to activate the SSCS the percentage dropped to 14.8%. Both of these findings provide evidence that educating nursing staff and physicians about early clinical signs of sepsis, while also providing reassurance and guidance with the facility's EGDT protocol can increase compliance and consequentially decrease morbidity and mortality.

The rest of the evidence presented by these seven studies suggests low implementation of EGDT to be the result of both educational deficits and resource deficits in the ED. Four out five of the patient centered studies had central venous pressure (CVP) and/or central venous oxygen saturation ($ScvO_2$) compliance below 30%. Staff assessed in the Nguyen et al. (2007) study were more compliant (64.8%) in implementing CVP and $ScvO_2$ monitoring. Problems with the implementation of CVP and $ScvO_2$ monitoring were attributed to an actual lack of transducers, or lack of knowledge of the nursing staff as of how to set up the transducers. A theory that could explain why Nguyen's et al. design yielded better results could be that his team educated the nursing staff on how to use transducers in the ED; his research team also purchased transducers and monitors that were to be used in the ED during the data collection. His team also provided continuous feedback to the staff, increasing morale and commitment to the protocol. Both Crowe et al. (2010) and O'Neill et al. (2012) found relatively high central venous insertion compliance (99.1% and 65% respectively) in their studies; yet they found very low compliance for CVP monitoring (81.9% and 27%) and $ScvO_2$ monitoring (28.2%, and 15%).

An explanation for these results provided by the authors (Crowe et al., 2010) could be that since this study was done retrospectively and EGDT is intended to be completed in 6 hours, patient data entered 6 hours after the start of the protocol might not have been pulled up by the computer algorithm used to retrieve the data. A more revealing explanation could be that either physicians didn't see the importance or necessity to order CVP or $ScvO_2$ monitoring as a part of EGDT or that nurses didn't feel comfortable setting up transducers or with the manipulation central venous lines. Both of these could lead to the conclusion that there is an

educational deficit in the ED in regards to global hypoxia management. These findings are also represented in both EGDT barrier surveys, as at least 38% of nurses agreed that CVP and/or $ScvO_2$ monitoring was a major barrier in compliance with EGDT as it was a form of invasive monitoring that they were unfamiliar with and that they had not be trained how to interpret. (Carlbom & Rubenfeld, 2007; Burney et al., 2012).

Another aspect that is not mentioned in the patient centered studies but is very strongly mentioned in the survey studies is the lack of nursing staff as a barrier to the implementation of EGDT protocols. Nurses are a very important and limited resource in the ED (Burney et al., 2012). They have a nurse to patient ratio ranging from 2:1 to 1:4 depending of the acuity of the patient population (Nguyen et al., 2007). Aspects of EGDT, such as performing venipuncture procedures. obtaining laboratory samples, obtaining blood cultures before antibiotic administration, and basic hemodynamic management do not prove to be very time consuming as they are routine in the ED. But CVP and $ScvO_2$ monitoring and administration of blood products can prove to be quite taxing for the nurses. Micek et al. (2006) has shown that the average length of stay (LOS) in the ED can be increased by almost 2 hours as a result of the need for these interventions. All these factors can be quite strenuous on the pace and quality of care an ED nurse can provide. Hiring extra staff might be needed or the creation of a “shock team” as proposed by Nguyen et al. to be called to the ED when a possibly severe septic patient arrives. These specially trained clinicians can handle the invasive monitoring and time consuming fluid resuscitation while the ED nurse can focus on the clinical needs of his or her other patients.

DISCUSSION

Transferring evidence-based practice from academic journals to clinical practice has proven challenging task. Very often there are barriers that prevent sound clinical changes from being accepted into clinical practice. The purpose of this paper was to identify the major barriers that prevent EGDT from being used in more EDs across the nation.

There are many aspects of the Surviving Sepsis Campaign (SSC) guidelines for EGDT that have not shown to be difficult to translate into clinical practice because they are common occurrences in most EDs. Obtaining laboratory analyses (eg. lactate clearance) and cultures on patients within one hour and before the administration of antibiotics has been shown to have high compliance; five out of the five patient centered studies did this. Providing fluid boluses in excess of 4 liters to maintain a MAP > 65 is also of common practice in the ED. It is when the EGDT protocol requires that nurses perform tasks that they are not accustomed to or demands resources that are scarce or nonexistent that implementation problems begin to be noticeable.

Lack of education as to the presenting symptoms of severe sepsis is a major barrier to the implementation of the SSC EGDT protocol. If severe sepsis cannot be identified in the ED, then it cannot be treated. Aside from education deficits that may be present among nurses and physicians in respect to identifying sepsis early, a major culprit might have been normotensive shock (Mikkelson et al, 2010). This form of shock has been shown by Mikkelson et al to be 15% less likely to be treated with the EGDT guidelines than the more common hypotensive shock seen in traditional septic patients.

This illustrates the importance of assessing patient's lactate clearance and $ScvO_2$ values as these can give further evidence as of the extent of global hypoxia that a patient is experiencing. Elevated 24 hour lactate levels are very conducive to increased morbidity and mortality (Mikkelson, 2010). The SCC maintains that lactate levels above 4 mmol/L are an indication to begin EGDT and aggressive resuscitation. Educating nurses in the ED about normotensive shock and the importance of lactate clearance values can increase the odds that patients will be identified and have the EGDT protocol initiated. Most ED's have the capability of obtaining lactate values rapidly as a point of care (POC) test.

Lack of educational training with CVP and $ScvO_2$ monitoring is a major barrier for nurses working in the ED. This is a barrier that can possibly be removed with nurse-focused educational courses on the set up and operation of the transducer at the bed side. One measurement that was not measured in any of the 7 studies was urine output. Urinary catheter insertion is a fairly common procedure in the ED that most nurses are proficient with. It is less invasive than a central catheter and can offer preliminary systemic perfusion data. It is mentioned in the SCC protocol that 0.5ml/kg/hr is the benchmark for adequate urine production; monitoring this is as a way to determine if organ dysfunction is present in a septic patient. But it was extremely underused in the reviewed studies.

LIMITATIONS

Limitations of this literature review are consistent with the limitations noted in the studies reviewed. Each study included, except for O'Neill et al. (2012) which was performed in a community hospital, was performed in large tertiary medical facilities, which leaves unanswered questions as what the barriers might be in smaller and perhaps more rural hospitals. The studies were also limited by the population size and by the fact that all except one of the survey studies were performed in a single ED. No meta-analyses were encountered during the research, which might have led to more universally applicable conclusions. The choice to use only domestic (U.S.) studies could have proven to be a limitations of the overall findings as it prevented the evaluation of foreign data on EGDT compliance and what solutions other authors might have experimented with in order to increase compliance rates. The limited key terms used to query the various databases were a limiting factor as well, as it could have limited the number of relevant research articles encountered. Furthermore, the limited database that could be accessed for this study could be interpreted as another limitation.

IMPLICATIONS

The findings from this study support that undergraduate nursing students and nurses practicing in the ED be educated about EGDT protocols. Nursing programs should include educational content that addresses the vital procedures needed to perform EGDT. These might include such procedures as how to properly set up transducers and how to analyze the data they provide. Academic facilities should spend more time instructing their students on critical care topics in order to prepare graduate nurses when they begin to work in the ED. Hands on experience should also be provided through simulations or other means. These educations interventions could also be effective in educations practicing nurses in the EDs who are ultimately responsible for implementing timely care to septic patients.

To address the competency issues that arise when nurse have a very limited exposure to invasive hemodynamic monitoring and are then expected to set up transducers and interpret the data they provide, ED nurses should make bi-yearly rotations through the ICU to maintain their skills in both setting up and interpreting transducers. This process would not only reduce the concern that nurses experience with invasive hemodynamic monitoring according to Burney et al. and Carlbom at al. (2007; 2010), but would also instigate collaboration between ED and ICU personal, which would in time yield better patient outcomes.

Further research should focus on which are the most effective ways to educate ED nurses and nursing students on how to perform and assess the invasive monitoring procedure required by EGDT.

CONCLUSION

In summary, this integrated review of the research has shown the important role that the ED nurse has in the identification and management of sepsis. As a clinician, the ED nurse is in a great position to initiate the SCC EGDT protocol when a patient meeting the guidelines arrives for care and is quickly identified. The data review has yielded two major barriers 1) lack of education of the nursing and physician staff in the ED regarding sepsis presentation and management, and 2) lack of resources to comply with EGDT guidelines according to the Surviving Sepsis Campaign. To address the first barrier, further education should be provided to ED nurses and nursing students in order for EDs to comply with EGDT. Various educations tools can be used to accomplish this, eg. simulations, classroom, case studies, etc. Articles such as Nguyen et al. (2007) show the great improvement that good education and positive feedback can have on compliance. Another form of education could come from a sepsis team that can be called to evaluate and assist in the management of care, while also educating the staff on clinical presentation and management of care, similar to what Mikkelsen et al (2010) accomplished in their research.

Mikkelsen et al (2010) also gives insight to resolve the second major barrier. By implementing sepsis teams that can assist in the diagnosis and management of sepsis in the ED, it relieves some of the time burden placed on ED nurse who must now care for a septic patient and her other patients. This team of experts would also alleviate the concerns that a very high

percentage of ED nurses feel towards invasive hemodynamic monitoring (Burney et al., 2007; Carlbom et al., 2012).

The evidence clearly shows that further research should focus on how to educate nurses and physicians and how to cost effectively increase resource in the ED to provide better care of patients in septic shock and to decrease morbidity and mortality.

APPENDIX

Table 1; Table of Evidence

Study	Summary	Evidence Level	Findings
Micek et al. (2006)	Prospective observational cohort of 120 patients in a large academic medical center. The study was done to evaluate a standardized hospital order set for septic shock in the ED. Staff was educated on sepsis diagnosis and protocol before the start of study. The study required extra time, resources, and equipment to implement the protocol.	Level II	Antibiotic administration within 3 hours (pre-intervention= 60%; post-intervention= 86.7%), Adequate intravenous fluids (58.3%; 88.3%), blood transfusion (6.7%; 20.0%), serum lactate measurement (16.7%; 78.3%), central venous oxygen saturation (1.7%; 48.3%), and vasopressors (100.0%; 71.7%). ED length of stay (5.8; 7.3 hrs).
Carlbom & Rubenfeld (2007)	National quantitative and qualitative phone survey with 24 physician directors and 40 nursing managers representing 53% of the 100 emergency departments surveyed.	Level III	The top four barriers for RN managers were: Nursing staff required (48%), identifying septic patients (38%), central catheter insertion (38%), and monitoring central venous pressure in the ED (38).
Nguyen et al. (2007)	Two year observational perspective cohort of 330 patients in an academic tertiary medical center with 65,000 ED visits a year. The study was	Level II	Compliance was as follows: Eligible patients initiated in the protocol at the start (51%), after 2 years (83%). Central venous pressure and central venous

	done to see if education and clinician feedback could increase compliance with EGDT. No additional staff was recruited, but new equipment was bought to measure central venous oxygen saturation.		oxygen saturation (1st year of intervention= 64.8%; 2nd year of intervention= 100.0%), Antibiotics within 4 hours (89.7%; 100.0%), central venous pressure goal met at 6 hours (35.6%; 100.0%), central venous oxygen saturation goal met at 6 hours (22.9%; 100.0%).
Mikkelsen et al. (2010)	Retrospective cohort study of 340 EGDT-eligible patients admitted through the University of Pennsylvania ED. A Severe Sepsis Consultation Service was put in place in order to assist with diagnosis and management of sepsis. No additional education was offered to the ED staff, including nurses.	Level II	Compliance was as follows: EGDT not initiated (42%), EGDT not completed once initiated (43%), Central venous catheter (pre-protocol=21.8%; post protocol=93.4%), vasopressors (9.2%;30.8%),and blood transfusion (9.2%;12.6%). When the Severe Sepsis Consultation Service was activated 71.2% of eligible patients had EGDT protocol initiated; when not only 14.8%.
Crowe et al. (2010)	Observational study of prospectively identified patients treated with EGDT compared with retrospectively	Level II	Compliance was as follows: adequate intravenous fluids (99%), central line insertion (99.1%), antibiotics in the first

	obtained data on patients treated before protocol implementation. Compliance of EGDT protocol was studied in 216 patients in a Tertiary level hospital with more than 85,000 ED visits yearly. No additional staff was recruited.		6 hours (97.7%), lactate values measured (93.5%), vasopressors (84.7%), central venous pressure (81.9%), central oxygen saturation measured (28.2%),and transfused blood (19%).
Burney et al. (2012)	Online survey offered to nurses and physicians (n=101) in an ED of a major urban academic medical center. Questionnaire was designed to assess perceived barriers to implementation of goal directed therapy.	Level III	Top 4 RN perceived barriers: physical space in ED (64.9%), nursing staff required (45.6%), delay in diagnosis and/or lack or recognition during triage (43.9%), central venous pressure/central venous oxygen saturation monitoring (40.4%).
O'Neill et al. (2012)	Non-concurrent cohort study of 98 adult patients entered into an EGDT protocol at a single community hospital over 9 months. Intended to measure compliance with the protocol. ED with 65,000 visits a year. No additional staff was recruited. Education was provided to physicians and nurses	Level II	Compliance was as follows: vasopressors (79%), antibiotics within 1 hour (78%), adequate intravenous fluids (68%), central line insertion (65%), central venous pressure (27%), and central venous oxygen saturation (15%).

in the ED.

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