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Implementing Early Goal-directed Therapy in the Emergency Setting: The Challenges and Experiences of Translating Research Innovations into Clinical Reality in Academic and Community Settings

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Abstract

Research knowledge translation into clinical practice pathways is a complex process that is often timeconsuming and resource-intensive. Recent evidence suggests that the use of early goal-directed therapy (EGDT) in the emergency department care of patients with severe sepsis and septic shock results in a substantial mortality benefit; however, EGDT is a time- and resource-intensive intervention. The feasibility with which institutions may translate EGDT from a research protocol into routine clinical care, among settings with varying resources, staff, and training, is largely unknown. The authors report the individual experiences of EGDT protocol development, as well as preimplementation and postimplementation experiences, at three institutions with different emergency department, intensive care unit, and hospital organization schemes.

Keywords

sepsis; early goal-directed resuscitation; knowledge translation

Estimates indicate that sepsis occurs at an incidence of 3.0 cases per 1,000 persons per year, resulting in approximately 750,000 affected persons annually in the United States. The number of cases per 100,000 population of severe sepsis far exceeds the number of cases of acquired immunodeficiency syndrome, venous thromboembolism, and both colon and lung cancer.[1-4] Sepsis ranks as the tenth leading cause of death in the United States, with an in-hospital mortality rate of 30% equating to approximately 215,000 U.S. deaths annually.[1,5] The total annual cost to the United States directly attributable to this disease is $16.7 billion, and the incidence of sepsis is projected to increase by 1.5% per annum, resulting in more than one million cases per year by 2020.[1]

During the past 30 years, numerous new therapeutic strategies for sepsis have been investigated. Unfortunately, these therapies have had little impact on the mortality rate in patients with sepsis, and the in-hospital mortality rate of the past decade approximately equals the mortality rates from the 1970s.[6] However, in 2001, Rivers et al. reported a substantial improvement in mortality among patients with severe sepsis and septic shock treated with early goal-directed therapy (EGDT).[7] EGDT refers to the concept of using a protocol that contains

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various predefined physiologic measurements as end points or goals for the resuscitation of critically ill patients. The aim of such a protocol is to achieve the predefined goals by using various therapeutic interventions in a stepwise manner.

In the randomized controlled trial performed by Rivers et al., the resuscitation protocol was instituted early in the patient's hospital course, specifically upon recognition of sepsis in the emergency department (ED). The study found that patients who received the protocol had a 16% absolute reduction in in-hospital mortality as compared with those patients who received standard care (30.5% vs. 46.5%).[7] The results of this study led to a grade B (supported by one large randomized controlled trial with clear-cut results) recommendation of the routine use of EGDT in the ED for patients who present with severe sepsis and septic shock as a part of the Surviving Sepsis Campaign guidelines. These recommendations have been endorsed by 11 professional societies, including the American College of Emergency Physicians and Society of Critical Care Medicine.[8]

The study by Rivers et al. was performed in the ED, with the research team present at the patient's bedside in the EGDT group[9] and in a section of their ED specially equipped and staffed to handle multiple critically ill patients. Thus, an important issue that the Surviving Sepsis Campaign guidelines did not address is the ability of such a protocol to be translated from a research environment to a clinical care setting in EDs and hospitals with varying resources, staff, and training. In fact, a recent survey indicated that EGDT is used in a minority of academic EDs, largely due to the complexity and invasiveness of the protocol.[10] Despite this, several investigators have reported favorable clinical impact after implementation of such a protocol.[11,12] The aim of this report is to describe the individual experiences of clinicians who have supervised the implementation of EGDT at each of three diverse hospitals, each of whom have all successfully operationalized the protocol in their ED. The following information from each hospital will be presented: 1) hospital model, 2) pre-EGDT implementation experience, and 3) post-EGDT implementation experience. Table 1 shows the hospital type, census, patient population, and outcomes of the centers participating in this report.

CAROLINAS MEDICAL CENTER

Hospital Model

Carolinas Medical Center (CMC) located in Charlotte, North Carolina, is a large, more than 800 bed, urban, community (non-university based) tertiary care facility and Level 1 trauma center that supports various residency programs as well as numerous large multispecialty private medical groups. The Department of Emergency Medicine supports a residency training program, and the ED evaluates more than 100,000 patient visits per year in 64 acute care beds. The hospital has full specialty and subspecialty services (most of which are not training program based), as well as adult medical, cardiac, surgical, and neurologic intensive care units (ICUs). CMC is the only indigent care hospital in Charlotte, and the high acuity of illness in the ED results in an annual admission rate of approximately 14% of all visits.

Preintervention Experience

The implementation of EGDT was a priority to the Department of Emergency Medicine and of vital importance to potentially improve morbidity and mortality in our patients with sepsis. However, given the structure of the hospital, it was initially recognized that with more than 1,200 physicians on medical staff, a significant effort would be necessary to assure that all admitting physicians (private and residency-based faculty) had ample opportunity to communicate opinions about the initiative and to be involved with planning, execution, and evaluation. Therefore, to rapidly and efficiently implement EGDT into clinical care, a task force was formed to address the following objectives: 1) critically evaluate the evidence

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supporting EGDT; 2) if evidence supports this therapy, develop an acceptable protocol to implement in the ED; and 3) create a process to evaluate the impact of the protocol on patient morbidity and mortality.

The task force was chaired by an emergency medicine faculty member and author of this report (AEJ) and cochaired by a member of clinical care nursing. The committee was made up of physicians from all the major admitting private medical groups; faculty departments within the medical center; members of the divisions of medical, surgical, and cardiovascular critical care; and pertinent members of clinical nursing and nursing administration. From the formation of the task force to the implementation of the protocol in the ED took nine months. The time effort of the chair and co-chair totaled in excess of 200 hours of work to complete the objectives of the task force. The time effort of other committee members, mostly attending committee meetings and reviewing documents, was approximately eight hours. The task force met quarterly during protocol development and continues this meeting schedule to review quality assurance (QA) data regarding all aspects of the protocol.

At the initial meeting of the task force, several major concerns were identified regarding the protocol and were perceived as potential barriers to realizing improved patient outcomes. The concerns raised by the task force included 1) the impact of the mixed ICU model (some closed, some open) on patient outcomes, given that this protocol had never been investigated in a community hospital with a similar ICU model; 2) the feasibility of a readily available “team” to assume the care of the patients and how the lack of such a team would potentially affect the care of protocol patients and other ED patients in the setting of overcrowding and the nationwide nursing shortage; 3) the impact of the lack of familiarity of ED nursing with many of the interventions required by the protocol, specifically central venous pressure (CVP) and central venous oxygen saturation ($ScVO_2$); and 4) the impact of the length of the protocol (six hours) on ED operations and patient flow.

The major concerns identified by the task force served as a basis to develop specific action plans in an attempt to proactively address these barriers. The action plans developed by the task force to address individual major concerns were as follows (the action plans are presented in order to correspond to the numbered concerns listed previously). 1) The committee developed a modified team approach in which the emergency physician (EP) acted as the physician leader of the team until the arrival of the admitting consultant, at which time care of the patient was transitioned to that individual. ED nurses were the primary caregivers of the patient. 2) Nursing in-services on all aspects of the protocol were designed and executed before initiation of the protocol. In addition, the specific monitoring aspects of the protocol were included in annual core competency training for all ED nurses. 3) In an attempt to assure optimal patient care and equal allocation of the protocol workload, the task force recommended a time frame of 90 minutes from initiation of the protocol to ICU arrival. This required arrangements with ICU nursing, administration, and hospital bed management to assure priority bed assignment to protocol patients.

Postintervention Experience

The implementation of EGDT has been well received by both the EPs and the admitting physicians at CMC. Approximately ten patients per month are identified as candidates and are treated with the protocol. The acceptance of the protocol by the ED and ICU nursing staff has been impressive and supportive. Overall, we have been encouraged by the positive perception that the staff have demonstrated and the positive impact on patient outcomes that we have realized as a result of implementing EGDT. However, we continue to face several ongoing challenges with the operational protocol. The major challenge is related to technical details regarding the catheter (PreSep; Edwards Lifesciences, Irvine, CA) and monitor (Vigilance; Edwards Lifesciences) that we use for $ScVO_2$ monitoring. The main problem relates to the fact

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that in order to avoid losing stored $ScVO_2$ trend data and to avoid recalibration of the optics module, the catheter must remain connected to a cable that plugs into the monitor. Thus, we have had trouble with losing cables and accessibility to additional cables in the event of loss. This frustration has led us to consider connecting the cable to the monitor and recalibrating the optics module of the catheter in vivo after arrival in the ICU. These issues result in a significant amount of time required for troubleshooting problems related to $ScVO_2$ monitoring and add an element of complexity that diverts physician and nurse attention away from other aspects of patient care.

Other challenges of the operational protocol include the need for continued nursing education given the number of patients per month who are entered into the protocol, as well as introduction of new staff on a regular basis. This education is included in the nursing staff core competencies, which are tested twice a year. In addition, the QA process, which is an absolutely necessary component of the operational protocol, occupies a significant amount of time from the chair and co-chair of the task force. The quality indicators we track include mortality, organ dysfunction, ICU and hospital length of stay, and EGDT component compliance (e.g., measurement of CVP and $ScVO_2$). We attempt to track cases of both patients who qualified for EGDT but were not treated and patients who were treated but were not candidates. In these circumstances, individual face-to-face feedback is given to care providers by the task force chair. These unforeseen challenges are manageable but are largely unmentioned by the expert recommendations and original investigators. Publication of the EGDT experience data was approved by the institutional review board and privacy board of Carolinas Healthcare System.

BETH ISRAEL DEACONESS MEDICAL CENTER

Hospital Model

Beth Israel Deaconess Medical Center, located in Boston, Massachusetts, is a large, 490-bed, urban, universitybased tertiary care facility and Level 1 trauma center. The hospital is a major teaching affiliate of Harvard Medical School and supports numerous residency and fellowship training programs. The Department of Emergency Medicine supports a residency training program, and the ED evaluates approximately 50,000 patient visits per year. The hospital has adult medical, cardiac, surgical, and neurologic ICUs, with 24-hour in-house board-certified intensivist coverage. There are a total of 60 dedicated ICU beds with approximately 4,100 admissions annually. The medical and surgical ICUs that admit the vast majority of septic patients from the ED at Beth Israel Deaconess Medical Center are considered “closed units,” meaning that the attending physician for any ICU patient must be a board-certified critical care specialist.

Preintervention Experience

The implementation of EGDT was initially proposed by members from the ED staff but quickly became a collaborative initiative, with members of the emergency medicine, medical intensive care, and anesthesia and critical care specialties all participating in the implementation effort. The Multiple Urgent Sepsis Therapies (MUST) protocol implementation team was created. This active workgroup of clinical champions held weekly taskoriented meetings for ten weeks during the planning phase. The importance of participation in the protocol from the nursing staff was realized upfront, and nursing representatives from each of the departments were included as key members of the MUST protocol implementation team.

During the planning phase, the creation of an organized approach was stressed. We wrote a handbook that outlined the rationale and approach and that served as an operating manual (available at www.mustprotocol.org). We also created a one-page bedside guide summarizing the protocol, as well as a number of posters that both advertised the protocol and served as

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informative summaries of protocol procedures. Finally, we created a nursing sepsis flow sheet by adapting our nursing trauma flow sheet that was already familiar to the ED nursing staff. Throughout the planning and organizational phase, the MUST protocol committee benefited from input from emergency medicine and critical care as well as physician and nursing perspectives.

Next, a stress on the training phase before implementation allowed all providers to learn about the protocol. The ED nurses received a three-hour didactic session in one-hour blocks covering the pathophysiology of sepsis, the theory of EGDT, and the practical use of CVP and $ScVO_2$ monitoring. Physicians were educated via grand rounds, online tutorials, protocol review during conference, and individual teaching at the bedside. ICU nurses were educated during 30- to 60-minute “mini-lectures” on a shift-by-shift basis, and ICU physicians were educated during rounds and didactic conferences, as well as during the online tutorials.

Postintervention Experience

The MUST protocol, which utilizes EGDT, is now standard care for patients with severe sepsis and septic shock at our institution. Early and active efforts from our multidisciplinary MUST protocol committee enabled a thorough and complete penetration into routine practice. We used a resource pager early on that allowed for clinicians to page a member of the MUST protocol implementation team with questions that arose during the course of clinical care. The practice of screening patients for occult hypoperfusion with measurement of venous lactate levels became routine with the credo “blood culture = lactate” and the standing order to measure a lactate level for anyone receiving a blood culture or who was otherwise suspected of having an infection. We also created two sepsis carts that contained all the supplies needed for the CVP and $ScVO_2$ monitoring and placement. The carts also contained protocol materials and the handbook, as well as other useful information such as drip charts for vasopressors and inotropic agents.

We encountered several practical barriers. The task of placing a central line in a timely fashion in a busy ED was known to be a challenge from the beginning. While there is no magic solution, we used time to line placement as a QA measure and provided feedback when the times were prolonged (more than 1.5 hours). We also found that transfer of cables from the ED to the ICU made the cables difficult to track and they were often lost. Given the tongue-in-cheek expression “if you put a bowling ball in an ED, it will be lost or stolen within a month,” we ended up locking the cables to the sepsis cart and foregoing the transfer of the $ScVO_2$ information. Finally, there was initially discussion about patients who “looked good,” responded to an initial resuscitation, or met hypoperfusion criteria based solely on lactate levels. In an agreement between the ED and ICU, we agreed to forego the ICU “evaluation,” and all patients meeting the enrollment criteria of 1) suspected infection, 2) two or more systemic inflammatory response criteria, and 3) systolic blood pressure <95 mm Hg or lactate level >4 mmol/L would be admitted to the ICU.

The MUST protocol implementation team now monitors the protocol and protocol compliance through our department's QA program. Patients who were treated with the protocol are identified, and the protocol flow sheets are examined to assure that the protocol is being followed. This process takes five hours per week. Additionally, patient outcomes, such as organ dysfunction and mortality, are tracked and weekly screening is performed for patients who may have met criteria, but were not enrolled, to ascertain if patients are being missed. We e-mail the providers involved in the patient's care case summaries, and either compliments or pointers on how to maintain compliance are given, as well as follow-up information on the patients' subsequent clinical course. In general, we try to maintain some level of accountability and surveillance to assure that the protocol remains part of our everyday clinical care.

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Publication of the EGDT experience data was approved by the institutional review board of Beth Israel Deaconess Medical Center.

PENROSE-ST. FRANCIS HOSPITAL SYSTEM

Hospital Model

Penrose-St. Francis, located in Colorado Springs, Colorado, is a 523-bed, two-hospital system that consists of a main hospital and a satellite community hospital. The main hospital is a Level 2 trauma center and has full ICU services and full subspecialty coverage except for pediatrics and obstetrics. The community hospital provides medical, surgical, and orthopedic services in addition to obstetric and pediatric services, but it lacks an ICU. The EDs have a combined volume of 83,000 patients per year and are staffed by board-certified EPs. The main hospital ED has an annual census of 38,000 patients with 28 acute care beds. This hospital serves a population with a very high acuity and an admission rate of 30%. The ICU at the main hospital is an operationally open 27-bed ICU with 50% of the patients cared for primarily by the intensivist service, 20% having an intensivist or pulmonary consult along with a primary attending physician, and 30% having only a hospitalist or surgeon attending physician.

Preintervention Experience

The impetus to establish a sepsis protocol that included EGDT was initiated by the EPs, based on anecdotal reports of underresuscitation of septic patients. The goal was to implement an educational program combined with a protocol that included EGDT to standardize the initial care and resuscitation of patients with severe sepsis and improve detection of patients with early or compensated sepsis. The EPs participated in a journal club to evaluate the pertinent literature as a group. This resulted in overwhelming support for the development of a sepsis protocol. The three main reservations from the EPs were as follows: 1) technical issues related to the requirement for an internal jugular or a subclavian central line, 2) reluctance to commit to a prolonged ED stay for the initial resuscitation of patients with severe sepsis, and 3) issues regarding training the nursing staff to use CVP monitoring and $ScVO_2$.

The sepsis program director (MR) met with the intensivist group to determine the feasibility and time course of the implementation of the program and to define the details of the protocol. Several potential problems were identified: 1) developing a protocol that included EGDT that was accepted by both the EPs and the intensivists, 2) training the EPs to recognize and appropriately resuscitate patients with severe sepsis, 3) technical training to encourage the use of internal jugular or subclavian central lines instead of a femoral central line (the most commonly used central venous access in the ED at this institution), 4) training nurses to measure CVP and $ScVO_2$, 5) ensuring that transferring care to the ICU from the ED of these patients would not interrupt the optimal care administered by the protocol, and 6) educating the medical staff (primarily the hospitalists) about the existence of an ED sepsis protocol and how that would impact patient care.

The protocol was written jointly by the EP and the intensivist groups. It included all the elements of the EGDT published protocols and the current ICU protocols for corticosteroid use and glucose control. The protocol required either an internal jugular or subclavian central line but did not require the use of continuous $ScVO_2$ monitoring. Instead, the protocol allowed for intermittent monitoring via blood draw from the central venous access. Additionally, the protocol was implemented in both of the hospital system EDs (main and satellite community) such that patients treated with the protocol at the main hospital ED were hospitalized in the ICU at the main hospital and patients treated with the protocol at the satellite community hospital were transferred directly from the community ED to the ICU at the main hospital.

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The protocol was reviewed and accepted by all of the intensivists and EPs. In addition to the initial literature review, all of the EPs were trained specifically on detection of occult sepsis with emphasis on a high degree of suspicion and liberal use of blood lactate levels to detect occult hypoperfusion. There was also specific training on the necessity of proper central venous access and techniques (e.g., ultrasound guidance) to improve success rates.

The ED nurses were trained regarding the protocol in two phases. First was a physician-led discussion of the merits of the proposed sepsis protocol and a brief literature review focusing on the inclusion criteria, baseline mortality, and proposed interventions. Second, the ED nurse educator led specific training courses on the technical aspects of CVP monitoring and $ScVO_2$ monitoring with the PreSep catheter. All of the nurses were required to attend this in-service.

One of the primary concerns was that implementing a time-intensive protocol such as this would adversely affect patient flow in the ED or overwhelm the ICU staff. Because the hospital does not have training programs or medical students, the workforce is significantly less than that of the initial study of EGDT performed by Rivers et al.[7] In fact, for six hours a day there may be only one physician (the EP) in the hospital for the care of medical patients. For this reason, the protocol did not specify a time requirement for either the initial ED resuscitation or a defined timeline for transfer to the ICU. Rather, the timing of these is handled individually based on ED and ICU volume as well as the availability of the intensivist. At the time of transfer from the EP to the intensivist, discussion of the patient's status includes a detailed discussion of the patient's response to the delivered therapy and the patient's exact progression through the protocol, so that therapy via the protocol could continue seam-lessly in the ICU.

The mechanism chosen to educate the hospital medical (physician) staff and inform them of the timeline of implementation of the protocol was by way of a dedicated hospital grand rounds on sepsis and EGDT delivered by one of the authors (MR). The grand rounds lectures were well attended by the medical staff, including hospitalists, cardiologists, and intensivists, and provided ample time for discussion. The two main hospitalist groups were contacted after the grand rounds to determine if any further questions or concerns existed. The sepsis protocol was implemented two months after the grand rounds and ten months after the initial ED journal club.

Postintervention Experience

The initial intention was to carefully track and abstract data on all patients with sepsis who were admitted through the ED. This is simply too labor intensive to do in a community setting without a functioning research infrastructure and labor force. Instead, a simpler data gathering method was used that consisted of voluntary physician reporting of cases where the sepsis protocol was used. This method, combined with the usual departmental QA process, has been sufficient to identify most issues of utilization and QA but is not robust enough to identify all cases where the protocol should have been implemented but was not because sepsis was unrecognized.

Maintenance of the program has required ongoing effort. Initially there was high compliance with the EGDT protocol, but over time there were more cases missed and protocol violations observed. Additionally, there has been a need for brief bimonthly meetings with the EPs, intensivists, and hospitalists to identify potential patients who were missed and identify ongoing problems with implementation of the protocol (this is done at the bimonthly Critical Care Committee meeting). There is also an ongoing need for feedback to the EPs on patient outcomes and ongoing championing to keep enthusiasm and morale present. Another unforeseen but real problem has been the need for ongoing nursing training on the proper use of the PreSep catheter and monitor, due in part to the relatively high turnover of nurses in the

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ED. We have included the training in the initial nurse orientation and annual skills review, it is discussed at the quarterly staff meetings, and two times a year there is a physician-led discussion of the pathophysiology of sepsis and a detailed description of the protocol.

DISCUSSION

Knowledge translation in clinical medicine refers to the transfer of high-quality research evidence into effective changes in clinical decision-making and patient management. The failure to translate new knowledge into clinical practice is a major barrier to human benefit from biomedical research evidence.[13] Factors that impede this knowledge translation are complex and include adequate systems support, understanding and synthesizing evidence, and finally implementing the evidence at the bedside.[14] In this article, we summarize the experience of three institutions in attempts to implement the best practice of EGDT for the treatment of patients with severe sepsis and septic shock in the ED.

The application of the best available research evidence into routine clinical practice has been studied in various diseases, with largely unimpressive results. The application of easy but proven therapy such as aspirin administration in the ED occurred in only 80% of patients with acute myocardial infarction before implementing a standing clinical pathway.[15] Thus, it is not surprising that more aggressive therapeutic interventions that are time and resource intensive, such as EGDT, have been slow to be adopted into clinical practice in the ED.[10] It is estimated that this gap in knowledge translation results in only half of the patients in the United States receiving the recommended acute medical care.[16]

As can be noted from the detailed experiences of each center in this report, there are numerous barriers to the incorporation of EGDT into routine clinical practice. The consistent themes of the barriers that we recognized among our institutions in this report include the following: 1) differences in ED functioning and staffing, requiring adaptations of the EGDT protocol to fit the needs of each individual institution; 2) reluctance on the part of both EPs and admitting physicians to adapt to changes in patient management essential to the EGDT protocol, which required intensive education and continued meetings at each institution; 3) both the availability of new catheters and monitors and the training of staff to use this equipment was time- and labor-intensive and required tailoring to the need of each institution; and 4) the time and resources required for structured QA and quality improvement was an enormous task at all of the institutions, including proving to be almost impossible in the community setting due to lack of available resources.

A seven-step model has been proposed for optimal knowledge translation and includes awareness, acceptance, applicability, able, acted on, agreed to, and adhered to.[14] During implementation of the best available evidence into clinical medicine, failures or “leaks” in the model are common. Such failures were observed during the implementation of EGDT at all of the institutions in this report. For example, “awareness” of the protocol by EPs and admitting physicians was a concern at CMC, given the large number of EPs and admitting physicians. Thus, a tremendous amount of effort, including multiple mandatory in-services for the EPs and multiple hospital medical staff informational mailings, was undertaken to address this potential leak in the model. Another concern at all the institutions was the potential effect of the protocol on ED throughput, which would be categorized in the “able” step of the model. This was addressed at all the institutions by designing a protocol that could be transitioned from the ED to the ICU. This method served to remove a potential undue burden of requiring six full hours of therapy to be delivered in the ED. Although we have presented only a few examples, we believe it would be beneficial for anyone considering implementation of EGDT to explore potential barriers and solutions based on a valid model such as the one discussed herein.

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The intention of this article is to simply share our experiences in the process of implementing EGDT in various clinical practice settings with the hope that others can use this information when considering a similar practice change. As outlined previously, we observed several consistent themes in the process of implementing EGDT at various institutions, such as the need for an implantation team of champions who drive cultural change, an organized approach, upfront training, and ongoing efforts to track and troubleshoot problems. Although the solutions to these themes are often institution specific, clinicians considering implementing this therapy may utilize our experiences to avoid, or at least have insight into, some of the barriers that may be encountered during the implementation process.

Finally, we should note that all of the authors of this report are in agreement that the implementation of EGDT at their respective institutions has resulted in improved patient care and outcomes among patients with sepsis. However, this benefit should be taken in the context of the knowledge that all of the authors are describing the clinical effectiveness of the protocol and thus are unable to definitively describe the number of patients who qualified for the protocol but were not enrolled and the number of patients who received EGDT who were actually not septic.

CONCLUSIONS

Despite the fact that barriers were encountered, the energy and time required to adapt and proceed with the protocol were acceptable compared with the estimated benefit gained by the patients. We hope that these experiences may assist clinicians considering a similar practice pattern change such as EGDT.

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Table 1

Description of Participating Hospitals

	Carolinas Medical Center[17]	Beth Israel Deaconess Medical Center[11]	Penrose-St. Francis
Hospital type	Community, teaching	University-based, teaching	Community, nonteaching
ICU type	Mixed	Closed	Open
ICU capacity (no. of beds)	70	60	27
Annual ED census	> 100,000	50,000	83,000 (combined)
Annual ICU census	6,000	4,100	1,300
EGDT candidates*	14	10	4
EG DT treated†	150	>300	90
Post-EGDT mortality reduction (%)‡	9	9	N/A

EGDT = early goal-directed therapy; ICU = intensive care unit; N/A = not applicable.

*The average number of candidates eligible to receive goal-directed therapy in the ED per month.

†The total number of patients treated with goal-directed therapy to date.

‡The absolute mortality reduction observed post-EGDT in the ED. For detailed methods on candidate identification and mortality reduction at Carolinas Medical Center and Beth Israel Deaconess Medical Center, see references 17 and 11, respectively. These data are not available from Penrose-St. Francis due to lack of institutional review board approval.