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Research Article

Utilization of Sepsis Advisor Software Clinical EMR Tool Reduces Mortality in High-Risk Septic Patients

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Abstract

Study Type: Retrospective study.

Level of Evidence: Level II

Background: Sepsis is the leading cause of death in U.S hospitals. Our institution implemented a Sepsis Advisor Software (SAS) that allows physicians to place orders quickly based on Surviving Sepsis Campaign guidelines (SSC). We hypothesize that use of the SAS tool results in decreased mortality in septic patients.

Methods: Electronic Medical Records were analyzed from 1/2016 to 3/2017, at a University Level I Trauma Center, for cases of sepsis defined by postoperative ICD-10 code A41, J18.9, N39.0 for age range 18 - 89. The cases were divided into two groups; sepsis advisor software used (SASu) and not used (noSAS). Independent t-test and Chi-Square test compared demographics, mortality, LOS, and treatment rapidity between the groups. Binary logistic regression analysis adjusted for severity of illness and mortality.

Results: 2,461 patients were diagnosed with sepsis between 1/2016 and 3/2017. SAS was used on 266 (10.81%). Antibiotics were administered within 3 hrs for 167 (62.78%) of SASu patients, compared with only 976 (44.46%) of noSAS patients (p = 0.0001). The total charges and cost were significantly higher among SASu patients compared to noSAS patients. After adjusting for age, BMI, risk of mortality, and severity of illness (SOI), SASu patients were 79% less likely to die if their SOI was Grade III or IV OR = 0.219; 95% CI (0.164 - 0.487), (P = 0.005); and 87.5% less likely to die if their risk of mortality was either Grade III or IV OR = 0.125; 95% CI (0.07 - 0.222), (P = 0.02).

Conclusion: Utilization of SAS at our hospital is associated with increased compliance with SSC and confers a mortality benefit in septic patients with high-risk of mortality and SOI.

Keywords: *Sepsis; Antibiotics; Infection*

Introduction

Sepsis is the leading cause of hospital mortality with more than 1.6 million cases diagnosed in the U.S each year [1]. Sepsis is the body's physiological response to bloodstream or tissue infection results in life-threatening organ dysfunction. Sepsis-related admissions account for $24 billion healthcare dollars spent per annum, making it the most expensive admitting diagnosis in the United States [2]. Additionally, it is a leading cause of mortality and readmission, prompting a 62% readmission rate within 30 days [3]. Surgical patients account for nearly ⅓ of sepsis cases and has 39% mortality rate in emergent cases and 30% of elective cases [4].

Onset of sepsis may be rapid and devastating in the absence of efficient treatment. Prompt identification of sepsis is crucial, as mortality increases by 8% for every hour of treatment delay. Conversely, rapid diagnosis and treatment early after sepsis onset dramatically improves outcomes [5]. The Surviving Sepsis Campaign (SSC) guidelines were created in an effort to help physicians quickly identify patients with probable sepsis and recommend the appropriate treatment in an efficient manner. SSC guidelines are updated regularly in accordance with evidence-based literature.

Although the 2016 SSC guidelines remove most "early goal-directed therapy" (EGDT) endpoints described in prior editions and advocate for patient-specific tailoring of hemodynamic therapy, strong recommendations for standardized care are still promoted, including: (1) Identification of sepsis and prompt source control intervention, (2) Empiric IV antibiotic administration within 1hr, (3) Resuscitation with 30 ml/kg crystalloid fluids within the first three hours, with additional fluids guided by reassessment of hemodynamic status, to a target mean arterial pressure (MAP) of 65mmHg and also normalizing lactate. Utilization of SSC guidelines has a proven mortality benefit when medical practitioners implement the guidelines as soon as sepsis is detected [5].

Our institution implemented an interactive Sepsis Advisor Software (SAS), enabling a "one stop" computer screen location for review of sepsis-related data (vital signs, culture results and lab values including WBC, lactate, renal function) and also order sets for additional tests, labs, or evidence-based empiric antibiotic regimens per organ system. We hypothesize that the SAS would increase compliance with SSC guidelines, and use of the SAS for patients would result in decreased mortality compared to patients for whom the SAS was not utilized.

Methods

Data from the institutional sepsis committee was retrospectively collected from electronic medical records on all patients with a diagnosis of sepsis, severe sepsis, and septic shock. The sepsis and trauma committee exists at our institution to maintain database on all sepsis patients in an effort to improve care and outcomes for these patients. The sepsis and trauma committee database included information on whether or not the SAS tool was utilized. Data was analyzed from January 2016 to March 2017. Sepsis was defined by postoperative ICD-10 code A41, J18.9, N39.0 for age range between 18 - 89 for all hospital patients with a diagnosis of sepsis based on ICD-10 code designation listed above. Demographics as well as variables included in SSC guidelines bundle were abstracted. Patients were dichotomized into two groups: SAS utilized (SASu) and SAS not utilized (noSAS). Information was distributed during grand rounds at our hospital on the utility of the SAS tool during its implementation into our EMR system. In addition, a hospital-wide email was sent out with detailed information and instructions on the use of the SAS tool. However, during the study period, it was up to the discretion of the ordering physician on whether or not they wanted to use the SAS tool in treating septic patients

Outcome variables included amount of fluid administered, timing of antibiotics, timing of serum lactate, serum lactate level, length of stay, mortality, cost, and charges. Outcomes were compared between the two groups. IBM SPSS Statistics for Windows, Version 22.0 software was used to perform statistical analysis. Chi-square was used to compare outcomes for categorical variables. ANOVA and independent t-test were used to compare continuous variables. P-values of less than 0.05 were at the level at which variables were considered to be statistically significantly different.

A binomial logistic regression was used to adjust for confounding variables in predicting mortality for the variables of age, BMI, initial lactate level on admission, risk of mortality, and severity of illness. The variables chosen for logistic regression were variables that were used to indicate severity of sepsis in patients. These were also the variables most frequently mentioned in the Surviving Sepsis Campaign.

Results

A total of 2,461 patients were admitted with a diagnosis of sepsis between January 2016 and March 2017, of these, SAS was used on 266 (10.81%). The age and BMI of patients was not statistically different between two groups. SASu patients had a higher risk of mortality and severity of illness grade ($p < 0.0001$). Antibiotics were administered within the first 3 hrs for 167 (62.78%) of SASu patients, while it was administered within 3 hours for only 976 (44.46%) of noSAS patients ($p = 0.0001$) (Table 2). Total charges, payments and cost were all significantly higher in SASu patients when compared to noSAS patients. Length of stay, age, BMI and fluid volume given were not significantly different between the two groups.

	SAS Used (n = 266)	NO SAS (n = 2195)	P-Value
	Mean (SD)	**Mean (SD)**	
Age	60.89 (17.745)	58.29 (17.68)	0.993
BMI	27.89 (12.97)	27.92 (15.68)	0.656
Payer Status	% [n]	% [n]	0.008
Medicare	62.41% [166]	50.30% [1104]	
Medicaid	10.15% [27]	13.17% [289]	
Private Insurance	15.79% [42]	22.19% [487]	
Self-Pay	11.65% [31]	14.35% [315]	
Risk of Mortality Score			0.0001
Grade I	0.75% [2]	1.00% [22]	
Grade II	3.38% [9]	11.94% [262]	
Grade III	12.03% [32]	18.86% [414]	
Grade IV	50.38% [134]	38.86% [853]	
Severity of Illness Grade			0.0001
Grade I	0	1.00% [22]	
Grade II	7.89% [21]	18.27% [401]	
Grade III	42.85% [114]	35.62% [782]	
Grade IV	48.49% [129]	42.73% [938]	

Table 1: *Demographics.*

**Chi-Square test used for categorical variables; **Independent t-test for continuous variables.*

Total charges, payments, and cost were higher in SASu patients. Totals charges were $24,762.90 higher in SASu patients ($P = 0.002$). Total cost was $6,377.94 higher in SASu patients ($P = 0.008$). Total payment was $4,025.76 higher ($P = 0.016$) in SASu patients. Overall, payment was nearly 20% higher in the SASu group (Table 2).

Fluids were more likely to be administered within 1 hour in 69.92% in SASu patients versus 62.60% in noSAS patients ($P = 0.05$). Additionally, fluids were more likely to be accurately dosed (i.e. 30 mg/kg) in SASu patients 43.23% vs. 31.11% ($P < 0.0001$) in noSAS patients. Antibiotics were more likely to be administered within 3 hours of presentation in SASu patients compared to noSAS patients (62.78% vs 44.46%) ($P < 0.0001$) (Table 2).

Mortality was similar between the two groups (14.66% vs 14.67%; $P = 0.997$) (Table 2), however, after adjusting for age, BMI, risk of mortality, and severity of illness, SASu patients were 79% less likely to die if their illness severity was Grade III or IV OR = 0.219; 95% CI (0.164 - 0.487), ($P = 0.005$); and 87.5% less likely to die if their mortality risk was either Grade III or IV OR = 0.125; 95% CI (0.07 - 0.222), ($P = 0.02$).

	SAS Used (n = 266)	NO SAS (n = 2195)	P-Value
	% [n]	% [n]	
Mortality	14.66% [39] Mean (SD)	14.67% [322] Mean (SD)	0.997
Total Charges ($)	126421.25 (202399.26)	101658.35 (173340.00)	0.002
Total Payments ($)	19850.20 (32389.01)	15824.44 (29681.07)	0.016
Total Cost ($)	30474.24 (56174.02)	24096.30 (50534.76)	0.008
LOS (Days)	11.14 (13.05)	9.9 (10.8)	0.025
1st Lactate Level	2.56 (1.8)	2.4 (2.1)	0.8
2nd Lactate Level	1.73 (1.72)	1.36 (2.2)	0.25
Fluid Volume Given	1722.11 (1373.36)	1542.53 (1429.14)	0.922
Fluid Volume Given ml/kg	22.31 (16.43) %[n]	19.82 (18.44) % [n]	0.362
Fluids Administered Within 1 Hour	69.92% [186]	62.60% [1374]	0.05
Fluids Administered 30 mg/kg	43.23% [115]	31.11% [683]	0.0001
Antibiotics Administered Within 3 Hours of Presentation	62.78% [167]	44.46% [976]	0.0001
Antibiotics Administered Within 1 Hour of Presentation	8.27% [22]	7.61% [167]	0.328
Length of Stay Less than 1 Day	3.38% [9]	2.55% [56]	0.912

Table 2: *Outcomes.*

**Chi-Square test used for categorical variables; **Independent t-test for continuous variables.*

Omnibus Tests of Model Coefficients was found to be statistically significant, $p < 0.0001$, Chi-Square of 53.04, DF 9. The Nagelkerke R Square was 0.398, which shows that 39.8% of variability of our dependent variable (mortality) was explained by the independent variables of (age, BMI, risk of mortality, and severity of illness). The Homer and Lemeshow Test was not statistically significant ($p = 0.989$).

Discussion

Sepsis is a leading cause of morbidity, mortality, expense, and accounts for between one-third to one-half of all hospital deaths [6]. Updated consensus guidelines from the Surviving Sepsis Campaign emphasize early identification of sepsis, prompt antibiotic administration, aggressive source control, appropriate antibiotic stewardship, and patient-specific tailoring of hemodynamic therapy with frequent reassessment to achieve improved outcomes [5]. Order sets, checklists, reminder cards, and EMR decision support have all been shown to increase compliance with SSC guidelines and improve sepsis associated mortality [7]. Texas Tech's University Medical Center developed the Sepsis Advisor Software (SAS) tool to increase physician compliance with current evidence-based SSC guidelines for improved care of the septic patient. The SAS tool can be seen in figure 1 and 2.

The SAS significantly improved timely empiric antibiotic administration at our university hospital. Antibiotics were administered within the first 3 hours for 167 (62.78%) of SASu patients, compared with only 976 (44.46%) of the patients without the tool ($p = 0.0001$).

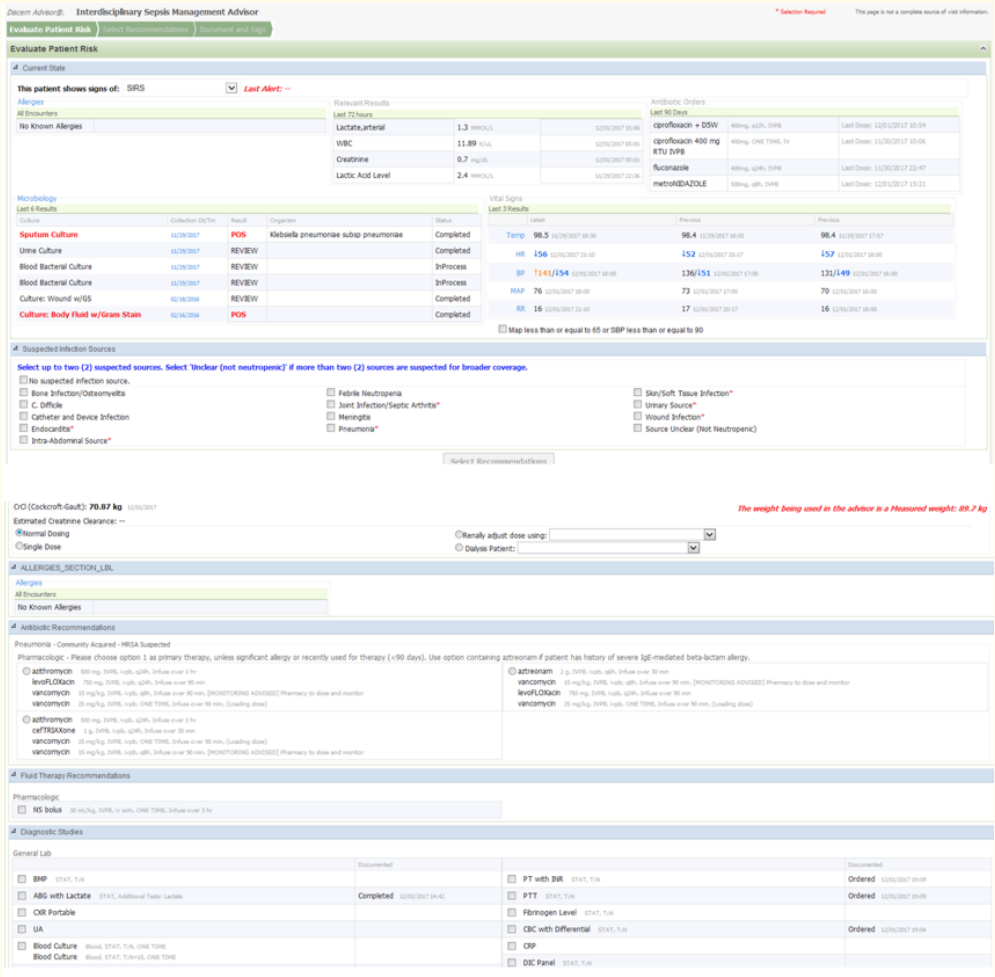

Figure 1 and 2: Sepsis advisor software tool.

Fluids were also more likely to be administered within 1 hour in 69.92% in the SASu group versus 62.60% in the noSAS group (P = 0.05). The fluid administered was also more likely to be accurately dosed (i.e. 30 mg/kg) in SASu patients 43.23% vs. 31.11% (P < 0.0001) in noSAS patients. Interestingly, the first and second lactate levels did not differ significantly between the two groups, possibly underscoring the importance of the initial time to fluid bolus.

Total charges, payments, and cost were all significantly higher among SASu patients when compared to noSAS patients. The SAS tool was used in more severely septic patients, who may have required additional treatment, resulting in the higher total cost for these patients. Length of stay, age, BMI and fluid volume given were not found to be significantly different between the two groups.

After adjusting for age, BMI, admission lactate level, mortality rick, illness severity, SASu patients were 79% less likely to die if their severity of illness was Grade III or IV and 87.5% less likely to die if their risk of mortality was either Grade III or IV. This marked mortality improvement may underscore that the SSC guidelines are most important in the sickest patients. Of note, the SAS tool was not used in patients with Grade I Illness Severity and was used in only 21 (4.98%) of Grade II illness severity patients. It would seem that physicians had a sense for which patients were at higher risk and chose to use the tool in this sicker population. Although the tool was used in sicker patients, overall use of the tool was poor at only less than 11%.

It is important to note that despite the improvement in early antibiotic administration with SAS tool, even in patients with SAS utilization, antibiotics were not administered within 3 hours in almost 40% of patients. Some possible barriers that would lead to the late administration of antibiotic to patients in both groups include: delays in processing the order; delays at the level of the physician putting in the order; delay in the pharmacist sending the antibiotics IV; delay in the administration of the antibiotic by the nursing staff. It is assumed that these barriers were present in both the SASu and noSAS groups, so they would not confound the outcomes.

Limitations to this study included retrospective review and a lack of SAS tool usage in patients with low risk of mortality score and severity of illness grade. Additionally, the tool did not address or encourage the use of repeated hemodynamic status assessments. While the tool provided organ system specific evidence-based empiric antibiotic choices, it did not encourage or track antibiotic stewardship in the form of proper de-escalation and timing. The use of SAS was left to the discretion of the ordering physician which is why it was only used on 10.81% of the postoperative septic patients. There was also a lack of identification of alternate confounding factors such as time to source control. Intensive care unit status was not accounted for between SASu and noSAS group which could explain why SAS patients were more expensive and had a greater severity of illness and risk for mortality.

Further studies should address additional secondary outcome variables such as hospital length-of-stay (los), intensive care unit LOS, discharge disposition (i.e. home versus skilled nursing). Increased usage of the SAS tool in lower grade illness severity patients might reveal whether the SSC guidelines are just as important in these lower-acuity septic patients. The length of time to set up the SAS as well as the cost associated can also be measured to see how reproducible this would be in different hospital settings.

Conclusion

This study adds to the literature endorsing SSC guideline adherence for improved mortality in septic patients. Additionally, use of the SAS tool improved physician compliance to SSC guidelines, resulting in improved mortality in high mortality risk and illness severity septic patients.

Author Contribution

Theophilus Pham: literature search, data analysis, writing, revisions.

Yana Puckett: data collection, data analysis, data interpretation, writing, revision.

Steven Brooks: study design, writing, revision.

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