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Rates and Timing of Central Venous Cannulation Among Patients with Sepsis and Respiratory Arrest Admitted by the Emergency Department

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Abstract

Objective—Clinical guidelines for the acute management of emergency department (ED) patients with severe sepsis encourage the placement of central venous catheters (CVC). Data examining the timing of CVC insertion among critically ill patients admitted from the ED are limited. We examined the hypothesis that prompt CVC insertion during hospitalization among patients admitted from the ED acts as a surrogate marker for early aggressive care in the management of critically ill patients.

Design—Retrospective cross sectional analysis of ED visits using 2003-2006 discharge data from California, State Inpatient Databases (SID), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality.

Setting—General medical or general surgical hospitals (n=310).

Patients—Patient hospitalizations beginning in the ED with the two most common diagnoses associated with CVC (sepsis and respiratory arrest.)

Interventions—None.

Measurements and Main Results—We identified the occurrence and timing of CVC using International Classification of Diseases, Clinical Modifications, 9th Revision procedure codes. The primary outcomes measured were annual CVCs per 1000 hospitalizations that began in the ED occurring emergently (procedure day 0), urgently (procedure day 1-2), or late (procedure day 3 or later). A total of 129,288 hospital discharges had evidence of CVC. In 2003 5,759 CVCs were

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placed emergently compared to 10,469 in 2006. The rate of emergent CVC/1000 increased annually from 228 in 2003, 239 in 2004, 257 in 2005, up to 269 in 2006. Urgent and late CVC rates trended down (p<.001). In a multilevel model the odds of undergoing emergent CVC relative to 2003 increased annually: 1.08 (95%CI, 1.03 to 1.12) in 2004, 1.19 (95%CI, 1.14 to 1.23) in 2005, and 1.28 (95%CI, 1.23 to 1.33) in 2006.

Conclusions—CVCs are inserted earlier and more frequently among critically ill patients admitted from the ED. Earlier CVC insertion may require systematic changes to meet increasing utilization and enhanced mechanisms to measure CVC outcomes.

Keywords

Catheterization; Central Venous; Emergency Medicine; Sepsis

Introduction

In the past 18 years the number of hospital visits with a code for central venous catheter insertion (CVC) more than quadrupled from 439,339 in 1993 to 1,968,244 in 2010.[1] In the Emergency Department (ED), ultrasound technology and Surviving Sepsis guidelines have facilitated and encouraged early CVC among critically ill patients to guide resuscitation and decrease mortality.[2-4] Additionally, the number of severely septic patients EDs will care for before admission to the intensive care unit (ICU) is on the rise. [5-7] According to the Healthcare Cost and Utilization Project (HCUP), the number of patients who entered the hospital from the ED with a principal diagnosis of sepsis increased from 198,909 in 1993 to 457,944 in 2006.[1]

The objective of this study was to examine utilization and timing of CVC among patients admitted from the ED in an environment of changing clinical approaches in the management of acute sepsis. CVC may be interpreted as a surrogate marker for aggressive management since invasive hemodynamic parameters (central venous pressure and central venous oxygen saturation) and the delivery of vasoactive medications both require large central vein access. There are currently no national databases that readily identify patterns of CVC utilization among patients admitted from the ED. Identifying the timing of aggressive resuscitation during hospitalization can provide information for system-wide severe sepsis strategies including efforts to meet demand and systems to help mitigate potential adverse evnts from CVCs inserted outside the ICU.

Methods

Databases and Study Population

We performed a retrospective cross-sectional analysis of hospitalizations that began in the ED using data from the Agency for Healthcare Research and Quality’s (AHRQ) HCUP California State Inpatient Databases (SID) from 2003 to 2006.[8] The California SID was chosen because of its large sample size, diverse patient population, and relevant clinical information. Records were limited to adult (18 years of age or older) stays in community acute-care (non-federal, non-rehabilitation) hospitals admitted from the ED. (Figure 1) Records were merged with The American Hospital Association (AHA) Annual Survey Database (Health Forum) and limited to general medical and general surgery service hospitals. Transfers between hospitals were excluded to eliminate the possibility of misclassifying the location and timing of procedures.

Clinical Classification Software (CCS), developed to categorize International Classification of Diseases, 9th Revision (ICD-9-CM) diagnoses from large administrative databases into clinically meaningful groups for the purposes of research, was used to assign diagnosis categories.[9,10] Records were included if the principal CCS diagnosis of sepsis (CCS= 2) or respiratory arrest (CCS=131) was present on admission meaning these conditions were present when the patient was admitted from the ED. Among all hospital records (not just those originating in the ED) sepsis and respiratory arrest were the two most common principal CCS diagnoses associated with CVC. Respiratory arrest was included because of the undifferentiated nature of critically ill ED patients and the common prevalence of respiratory arrest and infection in cases of presumed sepsis in the ED. The ICD-9-CM procedure code for CVC (38.93) was used to identify inpatient discharges with CVC. Discharges without evidence of CVC insertion were excluded from the analysis.

Power calculations were done assuming a 2% increase per year in the rate of early CVC. To account for comparison of multiple years, a Bonferroni correction was done with alpha = .0125. We estimated approximately 36,000 records would be necessary to detect a significant yearly difference with 80% power. Calculations were performed using G*Power (v 3.1.3, Dusseldorf, Germany).

Measures

Primary Dependent Variable—HCUP assigns the day that a procedure took place during the hospitalization relative to the hospital admission date. If a procedure takes place on the same day the patient is admitted, it is assigned to procedure day 0. Any procedure occurring on day 0 or day -1 was categorized as an “emergent CVC.” Procedures taking place on days 1-2 or on day 3 or more of hospital admission were categorized as cases that required “urgent” or “late” CVCs, respectively. The primary dependent variable of interest was expressed as emergent CVCs/1000 hospitalizations that began in the ED among patients with a principal diagnosis of sepsis or respiratory arrest present on admission.

Independent variables or covariates—Demographic, payer, and mortality data were collected from the SID. Medicare for individuals 18-65 years was categorized separately to represent the disabled or chronically ill. Elixhauser Comorbidity Software was used to assign comorbidities to each record.[11]

Hospital teaching status and urban or rural location originated from the AHA annual survey. The 2005 and 2006 California State Emergency Department Databases (SEDD), which contained treat and release visits, were concatenated with the 2005 and 2006 California SID discharge records to calculate annual ED volume. ED visits for years 2003 and 2004 reflect 2005 ED volume since no SEDD existed for those years.[12]

Data Analysis

Descriptive statistics were used to characterize the population.[13] Continuous data were examined for normality expressed with the appropriate statistic. The Kruskal-Wallis test was used to examine differences between non-normally distributed variables. The Cochran-Armitage test was used to examine trends. The Chi-square test was used to detect categorical differences.

Variables with a $P<.05$ on Chi-square testing were considered for the multivariate model. The multivariable model was multi-level to account for the effect of clustering of physician practices within hospitals.[14] Noting the co-linearity between age and payer status, models were run including the Medicare payer category in the payer reference group as well as a separate category. Since no appreciable differences were noted, we present our results keeping the Medicare payer in the reference category.

Two multivariable multi-level models were tested to examine the differences between emergent CVCs and CVCs inserted later during a hospitalization. The first compared emergent CVCs to all CVCs inserted during admission. The second compared emergent CVCs to urgent CVCs. We examined the distribution of residuals in order to assess model fit. Plots of residuals were examined to determine that they were normally distributed with a mean of zero. Interactions between ED annual volume and hospital teaching status were tested to explore associations among busier academic centers. All statistical analyses were performed in SAS (Cary, S.C) version 9.2.

Human Subject Protection

The University's Human Research Protection Office deemed this study exempt from consent.

Results

Between 2003 and 2006, 6,340,586 hospital stays began in California EDs (Figure 1). A total of 514,672 ED visits were admitted to 310 general medical or general surgical hospitals with a principal CCS diagnosis of sepsis or respiratory arrest present on admission. A CVC was placed in 129,288 (25%) of these admissions.

The number of emergent CVCs almost doubled from 5,759 in 2003 to 10,469 in 2006 (Table 1). The unadjusted rate of emergent CVC (inserted on day 0) over the 4 year period was 251 CVC /1000 hospitalizations compared to 237/1000 urgent CVCs (inserted on days 1-2) and 512/1000 late CVCs (inserted on day 3 or later). In comparison to urgent rates of CVC, the rate of emergent CVC increased from 2003 to 2006 (Cochran-Armitage, p<.001). Likewise, the rate of emergent CVC increased from 2003 to 2006 compared to late CVCs although the majority of CVCs were late insertions (Cochran-Armitage, p<.001) (Figure 2).

The total number of emergent CVCs among sepsis discharges more than doubled from 2,957 in 2003 to 6,290 in 2006 (Table1). Among visits for sepsis, emergent CVC rates increased more than urgent or late insertions. Rates for emergent cannulation increased by 5.1% (95% CI, 4.2-5.9) while rates for urgent CVC remained unchanged (0.3% difference, 95% CI -.1-1.1) and rates among late sepsis cases decreased overall by 5.4% (95% CI, 4.4-6.4). Increased emergent CVC rates were also noted for cases of respiratory arrest though by only 3.4% from 2003 to 2006 (95% CI, 2.3-4.6). Among respiratory arrest cases, rates for urgent CVC remained unchanged (1% difference, 95%CI -.08%-2.1%) while rates for late CVCs declined by 4.5% (95%CI, 3.2-5.7). Mortality among all three groups decreased during the 4 year time period (Table 2). Mortality decreased in the emergent CVC group by 3.7% (95% CI 2.2-5.3), in the urgent group by 5.1 % (95%CI, 3.6-6.7), and in the late CVC group by 2% (95% CI 1.0-3.0). Length of stay among survivors decreased by one day.

Table 4 and Table 5 show that in both multilevel models the odds of emergent CVC increased over time. Emergent CVC was more likely in rural hospitals, among the uninsured, and among visits indicating uncomplicated diabetes, drug abuse and coagulopathy although coagulopathy was not significant in the model comparing emergent to urgent CVCs. Visits indicating liver disease, congestive heart failure, metastatic cancer, paralysis and obesity were less likely to undergo emergent CVC although obesity was not significant in the model comparing emergent to late CVC and paralysis was not significant in the model comparing emergent to urgent CVCs. Among females emergent CVC was more likely than late CVC however less likely than urgent CVC. Emergent CVC was less likely among visits by patients in the oldest quartile but this finding was non-significant in the model comparing emergent to urgent CVC placement. There were no significant effects of ED visit volume or teaching hospital status in both adjusted models.

Discussion

In this study, the rate of emergent CVC among patients with a diagnosis of sepsis or respiratory arrest admitted from the ED increased from 2003-2006 indicating that aggressive management of critically ill patients may be occurring sooner during the course of hospitalization, possibly in the ED. The rise in emergent CVC rates observed by our data suggests that, among critically ill ED admissions, aggressive sepsis therapeutic pathways may be initiated sooner than before conforming to published guidelines and the acceptance of early goal directed therapy (EGDT) protocols.[3,15] If one is to accept that CVC represents more intense care, these data compliment prior research suggesting that aggressive therapy is occurring earlier among critically ill patients admitted from the ED.[16]

Though our objective was to characterize the timing of CVC utilization, we found patient outcomes similar to other sepsis studies using large databases. Unadjusted mortality and length of hospital stay decreased similar to Kumar's study which used a national sample of inpatient discharges.[17] There are data examining the association between CVC timing and outcomes. One small study found organ function worsened with each hour of CVC delay.[18] In a large population-based study, Walkey et. al. found decreased mortality among septic shock patients in whom CVCs were inserted upon hospital admission compared to those in whom a CVC was never placed.[19] In the initial EGDT study, patients in both the intervention and control arm underwent CVC in the first 6 hours. Decreases in mortality were attributed to those resuscitated to achieve specific hemodynamic goals, some of which were available only by CVC (e.g. central venous pressure, central venous oxygen saturation).[3] Conversely, CVC placement is likely to improve outcomes only if it leads to therapies (e.g. fluid administration, transfusions, inotropes, intubation and sedation or prevention of sudden cardiopulmonary complications) which are timed correctly for reversal of imbalances between supply and demand.[20] Levy et. al. found that increased sepsis bundle compliance decreased mortality although CVC related hemodynamic parameters were not shown to independently predict survival. [21,22] It's possible that CVC hemodynamic parameters may play a critical management role in early quantitative resuscitation, but their effect may be tempered over the course of a full sepsis admission.[23,24]

In both multivariable models, emergent CVC placement was more likely in rural hospitals compared to urban hospitals although there were few rural cases. In contrast, Wang et al. used a national sample and found that 15% of all severe sepsis cases presented to non-metropolitan statistical areas (MSA). These differences may be partially explained by how the AHA data designates rural hospital status and that this study used only data from the state of California.[25] Reasons for expeditious placement are likely related to delayed healthcare access in rural settings resulting in greater illness severity upon presentation.[26-33] Barriers to healthcare access and greater co-morbidity burden may also explain why the uninsured were more likely to require emergent CVC during their hospital visit.[31-33] Irrespective of the exact causes, populations traditionally challenged by access to the healthcare system may be more likely to require early CVC placement.

Similar to Walkey et. al.'s study, women were more likely to undergo emergent CVC on admission day 0 compared to later CVC.[19] However, females were less likely to undergo emergent CVC when compared to urgent CVC (days 1-2). Among females, reports of delay in accepted ED care processes have been observed in cases of acute myocardial infarction, stroke, and appendicitis. [34-37] Variable disease presentation and diagnostic challenges among females may partially explain these delays. Additionally, critically ill females may seek ED care sooner than males and require less intense ED services.[38] Lastly, differing prevalence of mediating co-morbidities between men and women in our first and second model may have also contributed to the inconsistent findings.

The likelihood of emergent CVC compared to later CVC decreased with age in our study though prior research indicates the incidence of sepsis is highest among those older than 70 years.[6,7] Physicians may be reluctant to offer aggressive therapy to some elderly patients because they may be thought unlikely to benefit. These patterns are well documented in cases of myocardial infarction and unstable angina and may explain delays in aggressive resuscitation among the critically ill.[39,40]

The co-morbidities associated with emergent CVC placement in both multivariate models were drug abuse and diabetes. ED patients with drug abuse often lack readily available peripheral access.[41] Acute diabetes management may require multi-lumen access for frequent blood draws and medication delivery. Delay in presentation among patients with drug abuse may also be a contributor. Although coagulopathy is cited as a relative contraindication, it did not seem to delay the timing of CVC in the acute setting.[42]

Emergent CVC was less likely in patients with metastatic cancer, congestive heart failure, liver failure and paralysis. Critical illness may be difficult to diagnose and act upon among chronically ill patients in the acute setting. Conversely, patients with chronic conditions may be closely monitored lessening the likelihood of presenting sicker to the health system.[43] Cancer patients may also have long-term tunneled catheters mitigating the need for emergent venous access. Obesity decreased the likelihood of emergent CVC compared to urgent CVC. Lack of technology or expertise may explain why emergent CVC was delayed in anatomically challenging patients.[44,45]

These data could not reliably identify where emergent CVCs were placed, however, EDs were likely involved. From 2001-2004, EDs cared for over 500,000 severe sepsis patients annually, a number likely to rise due to increasing ED visits.[646,47] Average length of ED stay for severely septic patients approaches 5 hours. Despite this window of opportunity, studies examining Surviving Sepsis guidelines find that only 25% of ED cases complete full bundle compliance. [6,21,22] These figures raise the possibility that EDs may not be sufficiently prepared to meet demands unless rates of emergent CVC rise. EGDT protocols may not be feasible without additional resources or without the development of non-CVC dependent EGDT protocols using non-invasive devices.[48-51] To resuscitate patients within 6 hours of arrival, ICU/ED collaborative teams will likely play a role. Technologies that improve the safety and efficiency of CVC insertion, such as ultrasound guidance, must be made widely available.[2,52,53] Central line associated blood stream infection (CLABSI) surveillance and prevention systems, widely implemented in ICUs but not EDs, will need to broaden their scope.[54,55] Despite great attention given to CLABSI prevention in ICUs, only one single center study has addressed the ED CLABSI rate, concluding that it is similar to the ICU rate.[56] There are no studies examining the feasibility and efficacy of CLABSI prevention strategies in the ED.

This study was constrained by limitations that pertain to administrative data.[57] We relied on timing of billing codes to identify CVCs but have no clinical details to establish whether patients denied consent or whether the patient's condition indeed merited a CVC. However, our focus was to track utilization to potentially inform system-wide strategies. While the specificity of ICD-9 procedures for major procedures is high, CVC may be considered a minor procedure and hence may be under-coded by some institutions.[58] The variability in hospital coding patterns may bias the data either away or towards the null and this may vary over time. Furthermore, some Elixhauser co-morbidities relevant to our analysis may have been under-coded limiting the ability to adjust for severity of illness. Elixhauser co-morbidities may weakly predict death in high-mortality subsets of ED patients admitted to the ICU compared to physiologic scores.[5960] However, Elixhauser comorbidities have performed well in predicting mortality in other studies compared to the Charlson comorbidity index.[61] Lastly, we did not examine CVC complications and the association of earlier CVC with adverse events requires further study.

Conclusions

Early CVC insertion rates are increasing among critically ill patients admitted from the ED. Units that initially care for critically ill patients, such as the ED, may require additional resources to meet increased utilization and to follow CVC outcomes.

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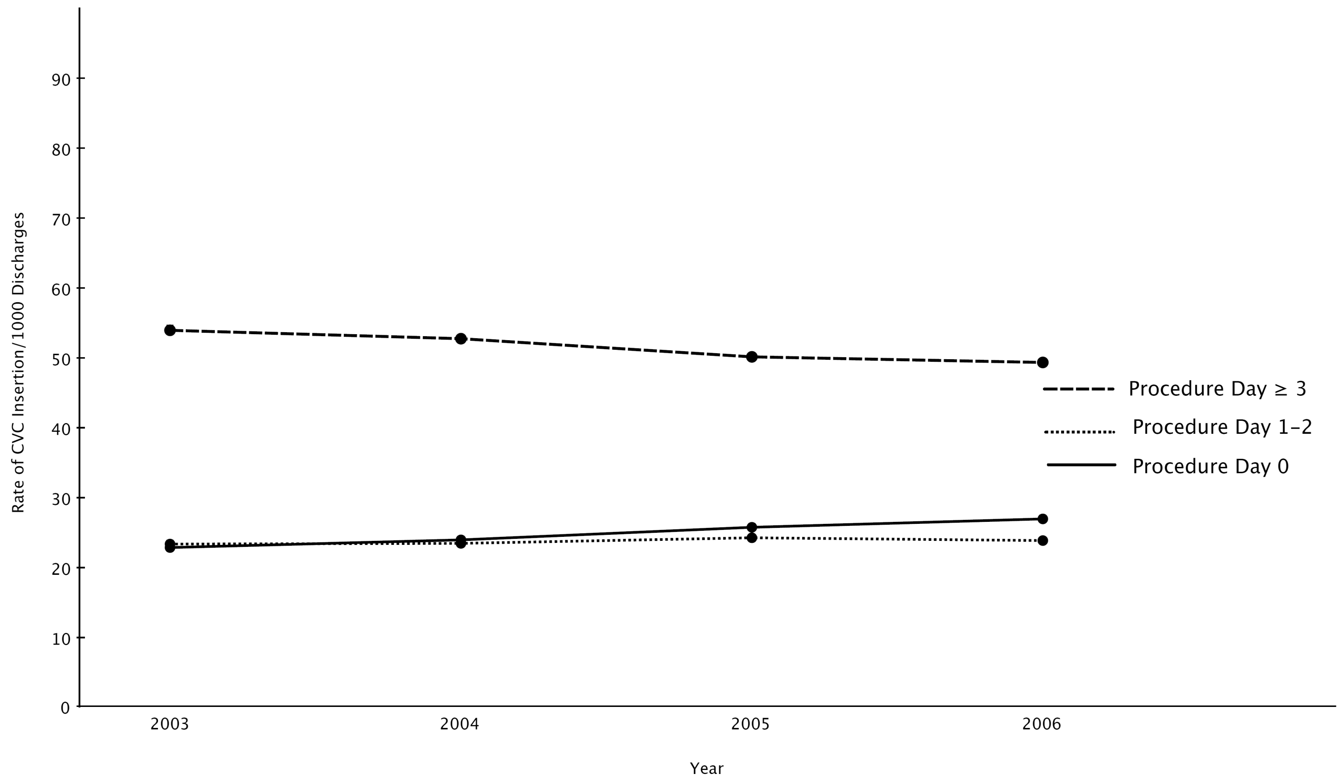

Figure 1.
Flow Chart Demonstrating Visits Included in the Study

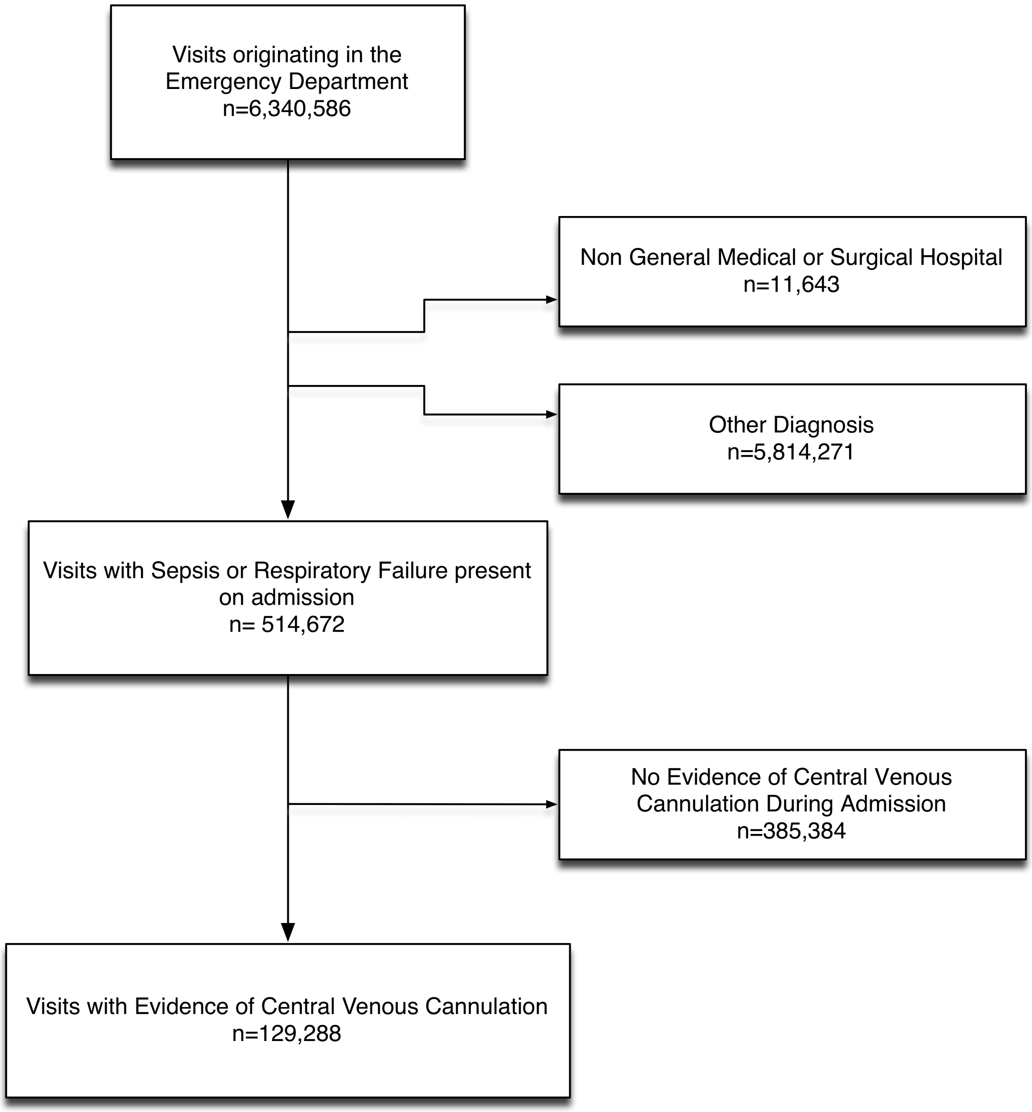

Figure 2.
Rates of Central Venous Catheter Insertion by Procedure Day During the Years 2003-2006

Table 1

Yearly Central Venous Cannulations by Time of Insertion and Diagnosis

	Emergent (PRDAY[a] 0)		Urgent (PRDAY[a] 1-2)		Late (PRDAY[a] ≥ 3)		Totals
Year	**n**	**%**	**n**	**%**	**n**	**%**	
2003	5,759	(22.8)	5,893	(23.3)	13,601	(53.9)	25,253
Sepsis	2,957	(20.0)	3,322	(22.5)	8,484	(57.5)	14,763
Respiratory Arrest	2,802	(26.7)	2,571	(24.5)	5,117	(48.8)	10,490
2004	7,152	(23.9)	6,998	(23.4)	15,784	(52.7)	29,934
Sepsis	4,036	(21.6)	4,238	(22.7)	10,402	(55.7)	18,676
Respiratory Arrest	3,116	(27.7)	2,760	(24.5)	5,382	(47.8)	11,258
2005	9,039	(25.7)	8,506	(24.2)	17,628	(50.1)	35,173
Sepsis	5,227	(23.5)	5,295	(23.8)	11,755	(52.8)	22,277
Respiratory Arrest	3,812	(29.6)	3,211	(24.9)	5,873	(45.5)	12,896
2006	10,469	(26.9)	9,263	(23.8)	19,196	(49.3)	38,928
Sepsis	6,290	(25.1)	5,725	(22.8)	13,053	(52.1)	25,068
Respiratory Arrest	4,179	(30.1)	3,538	(25.5)	6,143	(44.3)	13,860

[a] Procedure Day.

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Table 2

Mortality and Length of Stay Among Survivors Undergoing Central Venous Cannulations Emergently (Procedure Day 0), Urgently (Procedure Day 1-2) or Late (Procedure Day 3 or Later) in the State of California from 2004-2006

	2003		2004		2005		2006		
Died[b]		**%**		**%**		**%**		**%**	**p<.001**[a]
Emergent	2,276/5,759	(39.5)	2,606/7,152	(36.4)	3,198/9,039	(35.4)	3,749/10,469	(35.8)	
Urgent	2,050/5,893	(34.8)	2,171/6,998	(31.0)	2,679/8,506	(31.5)	2,747/9,263	(29.7)	
Late	3,770/13,601	(27.7)	4,228/15,784	(26.8)	4,541/17,628	(25.8)	4,936/19,196	(25.7)	
LOS Survivors[c] (Days)	Median	IQR	Median	IQR	Median	IQR	Median	IQR	
Emergent	10	6-16	9	6-16	9	5-15	9	5-15	0.005[d]
Urgent	11	7-18	10	6-17	10	6-16	10	6-16	0.001[d]
Late	17	10-27	16	10-26	16	10-25	16	10-25	<.001[d]

[a] Cochrane-Armitage.

[b] 25 Missing.

[c] Length of Stay.

[d] Kruskal-Wallis.

Table 3

Hospital and Encounter Level Characteristics of 129,288 Hospital Discharges by Timing of Central Venous Cannulation Representing Emergent (n=32,419), Urgent (n=30,660), and Late (n=66,209) Procedures.

	Emergent CVC (PRDAY[b] 0)		Urgent CVC (PRDAY 1-2)		Late CVC (PRDAY ≥3)			
	n	(%)[a]	n	(%)[a]	n	(%)[a]	Totals	p value[c]
Hospital Level								
Non Teaching Hospital	21,940	(24)	22,475	(25)	45,992	(51)	90,407	<.0001
Teaching Hospital	10,479	(27)	8,185	(21)	20,217	(52)	38,881	
Urban Hospital	31,704	(25)	30,171	(24)	65,545	(51)	127,420	<.0001
Rural Hospital	715	(38)	489	(26)	664	(36)	1,868	
ED Annual Visits								<.0001
<30,603	7,965	(24)	7,934	(24)	16,853	(51)	32,752	
30,603 to 40,599	7,271	(23)	7,461	(23)	17,179	(54)	31,911	
40,600 to 51,270	8,515	(26)	8,034	(25)	16,027	(49)	32,576	
>51,270	8,668	(27)	7,231	(23)	16,150	(50)	32,049	
Encounter Level								
Sex [d]								
Female	16,061	(25)	16,080	(25)	32,006	(50)	64,147	<.0001
Age								
18-45	5,281	(28)	4,493	(24)	9,275	(49)	19,049	
46-64	10,768	(27)	9,783	(24)	20,057	(49)	40,608	
65-74	6,096	(24)	5,885	(23)	13,159	(52)	25,139	
75+	10,274	(23)	10,499	(24)	23,718	(53)	44,491	
Insurance Status [e]								
Privt Ins/HMO	5,498	(18)	5,505	(18)	19,969	(64)	30,972	<.0001
Medicaid	6,306	(27)	5,368	(23)	11,999	(51)	23,673	
No Insurance	2,797	(33)	1,998	(23)	3,792	(44)	8,587	
Medicare Old	14,164	(23)	14,319	(24)	32,344	(53)	60,827	
Medicare Young	3,647	(26)	3,462	(24)	7,094	(50)	14,203	
Elixhauser Co-Morbidities								
Fluid and Electrolyte Disorders	18,185	(25)	17,133	(24)	36,367	(51)	71,685	0.0005
Congestive Heart Failure	9,632	(23)	9,764	(24)	21,764	(53)	41,160	<.0001
Chronic Lung Disease	9,383	(25)	9,245	(24)	19,330	(51)	37,958	0.0016
Uncomplicated Diabetes	7,173	(27)	6,667	(25)	13,130	(49)	26,970	<.0001
Coagulopathy	5,434	(26)	4,905	(24)	10,502	(50)	20,841	0.0012
Renal Failure	5,447	(24)	5,358	(23)	12,308	(53)	23,113	<.0001
Liver Disease	3,003	(26)	2,872	(25)	5,477	(48)	11,352	<.0001
Alcohol Abuse	2,966	(29)	2,533	(24)	4,871	(47)	10,370	<.0001
Drug Abuse	2,846	(34)	1,873	(22)	3,606	(43)	8,325	<.0001

	Emergent CVC (PRDAY[b] 0)		Urgent CVC (PRDAY 1-2)		Late CVC (PRDAY ≥3)			
	n	**(%)[a]**	**n**	**(%)[a]**	**n**	**(%)[a]**	**Totals**	**p value[c]**
Obesity	2,330	(26)	2,556	(28)	4,206	(46)	9,092	<.0001
Complicated Diabetes	2,274	(22)	2,367	(23)	5,845	(56)	10,486	<.0001
Paralysis	2,182	(24)	2,150	(23)	4,844	(53)	9,176	0.0028
Elixhauser Co-Morbidities								
Metastatic Cancer	1,257	(22)	1,335	(24)	3,071	(54)	5,663	<.0001
Arthritis	896	(24)	902	(24)	1,983	(52)	3,781	0.126
Solid Tumor (no metastasis)	851	(23)	853	(23)	1,936	(53)	3,640	0.0263

[a]Row percentages indicated.

[b]Procedure Day.

[c]Chi-square.

[d]112 Missing.

[e]26 Missing.

Table 4

Model 1 Comparing Emergent CVCs to CVCs Inserted After Procedure Day 0

Variable	Odds Ratio	95% Confidence Limits	p value
Year			
2003	*ref.*		
2004	1.08	1.03 - 1.12	0.0005
2005	1.19	1.14 - 1.23	<.0001
2006	1.28	1.23 - 1.33	<.0001
Hospital Level Variables			
Urban Hospital	*ref.*		
Rural Hospital	1.84	1.37 - 2.47	<.0001
Non-Teaching Hospital	*ref.*		
Teaching	1.03	0.95 - 1.13	NS
Annual ED Visits			
<30,603	*ref.*		
30,603-40,599	0.99	0.89 - 1.09	NS
40,600-51,270	1.10	0.98 - 1.25	NS
>51,270	1.05	0.91 - 1.21	NS
Encounter Level Variables			
Female	1.06	1.03 - 1.09	<.0001
Age			
65-74	*ref.*		
18-45	1.00	0.94 - 1.05	NS
46-64	1.01	0.97 - 1.06	NS
75+	0.96	0.92 - 0.99	0.0066
Primary Payer			
Private Insurance/HMO	*ref.*		
Medicaid	0.98	0.93 -1.02	S
No Insurance	1.23	1.16 -1.30	<.0001
Medicare Age < 65	0.99	0.94 -1.05	NS
Elixhauser Co-Morbidities			
Fluid and Electrolyte Disorder	1.05	1.02 -1.07	0.0010
Diabetes	1.12	1.09 - 1.16	<.0001
Coagulopathy	1.07	1.03 - 1.11	0.0002
Drug Abuse	1.37	1.30 - 1.45	<.0001
Paralysis	0.94	0.89 - 0.99	0.0263
Liver Disease	0.93	0.88 - 0.97	0.0023
Congestive Heart Failure	0.92	0.89 - 0.95	<.0001
Metastatic Cancer	0.91	0.85 - 0.97	0.0052
Diabetes w/Chronic Complications	0.91	0.86 - 0.96	0.0002

Variable	Odds Ratio	95% Confidence Limits	p value
Solid Tumor	0.97	0.90 - 1.06	NS
Obesity	1.01	0.96 - 1.07	NS
Alcohol Abuse	1.02	0.97 - 1.07	NS
Renal Failure	1.00	0.96 - 1.04	NS
Chronic Lung Disease	1.00	0.97 - 1.03	NS

Table 5

Model 2 Comparing Emergent CVCs (Inserted on Procedure Day 0) to Urgent CVCs (Inserted on Procedure Days 1-2)

Variable	Odds Ratio	95 % Confidence Interval	p value
Year			
2003	*ref.*		
2004	1.05	1.00 - 1.11	0.0434
2005	1.10	1.05 - 1.15	0.0002
2006	1.17	1.11 - 1.23	<.0001
Hospital Level Variables			
Urban Hospital	*ref.*		
Rural Hospital	1.39	1.05 - 1.84	0.0410
Non-Teaching Hospital	*ref.*		
Teaching	1.07	0.97 - 1.18	NS
Annual ED Visits			
<30,603	*ref.*		
30,603-40,599	0.99	0.89 - 1.10	NS
40,600-51,270	1.08	0.95 - 1.22	NS
>51,270	1.06	0.91 - 1.22	NS
Encounter Level Variables			
Female	0.95	0.92 - 0.98	0.0010
Age			
65-74	*ref.*		
18-45	0.94	0.88 - 1.00	NS
46-64	0.96	0.91 - 1.02	NS
75+	0.95	0.91 - 1.00	NS
Primary Payer			
Private Insurance/HMO	*ref.*		
Medicaid	1.05	0.99 - 1.10	NS
No Insurance	1.19	1.11- 1.28	<.0001
Medicare Age < 65	1.01	0.95 - 1.08	NS
Elixhauser Co-Morbidities			
Fluid and Electrolyte Disorder	1.01	0.98 - 1.05	NS
Diabetes	1.06	1.02 - 1.10	0.0052
Coagulopathy	1.04	1.00 - 1.09	NS
Drug Abuse	1.33	1.24 - 1.42	<.0001
Paralysis	0.95	0.89 - 1.02	NS
Liver Disease	0.86	0.81 - 0.92	<.0001
Congestive Heart Failure	0.95	0.92 - 0.99	0.0087
Metastatic Cancer	0.91	0.84 - 0.99	0.0222

Variable	Odds Ratio	95 % Confidence Interval	p value
Diabetes w/Chronic Complications	0.98	0.92 - 1.05	NS
Solid Tumor	0.98	0.88 - 1.08	NS
Obesity	0.88	0.83 - 0.94	<.0001
Alcohol Abuse	0.97	0.91 - 1.04	NS
Renal Failure	1.01	0.96 - 1.05	NS
Chronic Lung Disease	0.99	0.95 - 1.02	NS

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