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Two hospitals with 1 trauma system: a joint approach to the care of the injured patient

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Abstract

BACKGROUND: Trauma centers are closing at an alarming rate, but the need for trauma care persists. This article shows the sustainability and feasibility of a joint trauma system whereby 2 university-affiliated hospitals function as a single trauma center system in a moderate-sized city.

METHODS: Since 1994, 3 days per week, trauma patients are transported by emergency medical services (EMS) to hospital A. The other 4 days they are transported to hospital B. Trauma registry data from 1994 to 2008 were analyzed. Cost data were also examined.

RESULTS: The joint system admitted 28,338 trauma patients. On each center's nontrauma days, trauma team activation was required infrequently. The 2 centers share costs; they perform joint outreach, educational training, and quality control. The joint trauma system has been sustained since 1994.

CONCLUSIONS: Two hospitals functioning as a single trauma center system is a viable model of care for injured patients in a moderate-sized city with mostly blunt trauma.

There is a crisis in trauma care in the United States. Trauma is a major cause of morbidity and mortality in the United States. Each year, there are 37 million emergency room visits and 2.6 million hospital admissions for trauma.[1] The National Trauma Institute reports that trauma has a greater effect on years of productive life lost than any other disease.[1] Injuries that occurred in the year 2000 had lifetime medical care costs of over US $80 billion; in addition, there were an estimated $184 billion lost from nonfatal injuries and $142 billion in lost productivity from fatal injuries.[2] Additionally, according to the Centers for Disease Control, unintentional injury (which includes poisoning) was the leading cause of death for individuals aged 1 to 44 years between 1999 and 2007.[3] This does not include suicide and homicide. Meanwhile, among all age groups, between 1999

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and 2007, unintentional injury was the 5th leading cause of death.[3] Despite the massive numbers of hospitalizations for injury, trauma centers can no longer afford to stay open. Between 1983 and 1991, 66 trauma centers closed or became "de-designated."[4] Between 1990 and 2005, the rate of trauma center closure accelerated, with 339 trauma centers closing.[5] This represented one third of all trauma centers in the United States during this period.[5] Between 2001 and 2004, 30 trauma centers closed.[6]

Reasons for trauma center closures are myriad but principal among them is the limited reimbursement and lack of reimbursement for hospital services. This is especially true for urban trauma centers that have a high volume of penetrating trauma. In this regard, trauma centers are classically viewed as nonprofitable, serving higher proportions of uninsured patients and underinsured patients than nontrauma centers.[5] In a 1992 report by Dailey et al[4] on trauma center closures, none of the of the 14 closed urban/inner city trauma centers responding to their survey reported making a profit from their trauma services, but rather they reported a mean loss of $1.5 million over the 12 months preceding trauma center closure. Similarly, none of the 27 closed suburban trauma centers responding to the survey reported making a profit from their trauma services; their mean estimated loss for the 12 months before trauma center closure was $1.26 million. The lack of reimbursement coupled with the high institutional cost of trauma care is a daunting problem.[7] Further contributing to this crisis in trauma care are the lack of specialists and the lack of interest from physicians and administration. The closure of trauma centers adds pressure to those that still remain to handle greater volumes of patients and often forces patients or emergency medical services (EMS) personnel to travel greater distances to find an appropriate level of care.[2,6] Alternative models to sustain the viability of trauma centers are needed to avert a deepening crisis. We show the sustainability and feasibility of a joint trauma system whereby 2 separate university-affiliated medical centers work in collaboration to care for injured patients.

Materials and Methods

In the early 1990s, the hospitals in Omaha, NE, like those in many other parts of the United States, were under intense financial duress. Since the 1990s, this major metropolitan area has increased in size to a recent population of approximately 800,000 but has retained a limited trauma volume per capita, especially compared with trauma centers in larger urban areas. Given the limited trauma volume, it was jointly decided to combine trauma coverage at the 2 major university-affiliated medical centers (University of Nebraska Medical Center and Creighton University Medical Center) in 1994. The joint system was set up so that 1 hospital provides trauma coverage 3 days per week (ie, Tuesday, Friday, and Sunday). The other center provides coverage 4 days per week (ie, Monday, Wednesday, Thursday, and Saturday) perennially. This joint trauma program only applies to trauma patients brought to the hospital via EMS personnel. Each trauma center is responsible for its own "walk-in" trauma. In the case of a mass casualty, the trauma center of the day receives the initial 4 trauma patients; the second hospital then becomes active and treats the next 4 patients. Subsequently, the 2 hospitals alternate.

Because the 2 centers are only 2 miles apart with short drive times between the facilities, it is exceedingly rare for a critically injured patient not to be able to be transported to the trauma center of the day. In the highly unusual event that a critically ill injured patient arrives at a facility on its nontrauma day, coverage is initially provided by surgical residents and board-certified emergency physicians. Each hospital is staffed 24 hours per day 7 days per week by surgical residents and board-certified emergency physicians. The on-call trauma surgeon would also respond.

The residents rotating on the trauma service and trauma surgeons only provide coverage at their native institution. Both hospitals have maintained an in-house trauma surgeon on their respective trauma days. At both centers, trauma surgeons also participate in acute care surgery call. However, only trauma surgeons at hospital A also provide critical care coverage. At both institutions, attending trauma surgeon reimbursement for in-house call is accounted for in the base salary. Although there is an incentive program at each institution, there is no additional salary support for home call.

At the inception of the joint trauma program, the trauma medical director for both hospitals was also the medical director for the Omaha Fire Department. He discussed the joint program plans with the EMS providers. Because the prehospital program is paramedic based and protocol driven, there was no additional EMS training required or additional cost for this. Furthermore, over about 6 months before implementation of the joint trauma program, the trauma medical director met with the authorities at the 4 other major hospitals (nontrauma centers) in the Omaha area and advised them of the plans. There were both individual and group meetings with personnel from these hospitals. Additionally, the marketing departments at both university-affiliated hospitals sent informational material to the outlying/regional institutions and other EMS providers. Early on, as requests for transfer of patients from outlying facilities came in to the nontrauma center of the day, they were passed over to the trauma center of the day. Over approximately the next year, the regional referral medical centers gained familiarity with the joint trauma system, so that calls for the transfer of injured patients were rarely made to the nontrauma center of the day. Hence, in the highly infrequent scenario, when the nontrauma center of the day is contacted, the call is transferred to the trauma center of the day. However, in the rare event that transfer to a specific surgeon or facility is requested by a patient or

Table 1 Patient demographics, 1994–2008

	Hospital A	Hospital B
Total trauma patients	15,234	13,104
Blunt trauma (%)	90	86*
Mechanism (%)		
Fall	36	25
Motor vehicle/motorcycle crash	30	37
Stab	2.5	3.8
Gunshot wound	4.5	7.2
Other	27	27
Arrived from (%)		
Scene	52	72*
Transfer	23	18
Other	25	10
Injury Severity Score (ISS) >5 (%)	23.2	29.8*
Glasgow Coma Score (GCS) <8 (%)	8.7	12.0*
Mortality rate (% of trauma admissions)	5.2	6.4*

*All values that were examined were significantly different ($P < .01$) between the 2 hospitals.

facility, then that surgeon/facility can accept the patient regardless of which hospital is the trauma center of the day.

Initially, there was a single trauma director who oversaw trauma care at both centers; he was a trauma attending at both facilities. As the programs evolved, they each acquired their own trauma directors and their own complement of trauma attendings. Quality control and oversight measures that were gradually incorporated included monthly joint peer review meetings, morbidity and mortality conferences, and discussion of system-related issues. Furthermore, given the extensive crosstalk between the 2 hospitals, both were apprised if a patient previously treated at 1 hospital goes to the other hospital. This happened infrequently, and patients were advised to pursue their care at whichever institution they prefer.

This program has been sustained without interruption since its inception in September 1994. In 2008, our joint system received comprehensive designation by the state of Nebraska, which is equivalent to American College of Surgeons (ACS) level 1 trauma center designation. However, at present, to our knowledge, the ACS has not accredited joint trauma programs.

We examined the trauma registry data of both institutions for admissions, mortality, and trauma team activations for the 1st 15 years since the joint trauma system's inception (ie, from late 1994 to the end of 2008). Where indicated, the chi-square test or Wilcoxon rank sum analyses were used for statistical analyses in consultation with the biostatistics department of the College of Public Health at the University of Nebraska Medical Center. A P value less than or equal to .05 was considered significant. Expense data for 2008 were also gathered for each facility. In these calculations, for definition purposes, direct cost was any expense that was billed to the patient for hospital services in 2008. This included a facility fee that includes labor, medications, supplies, operating room time, and so on. Indirect cost was any expense that was not billed to the patient but was the overhead cost of doing business in 2008. Examples include space, electricity, and costs for departments that were not directly involved in patient care, such as finance, quality control, and so on. In these expense calculations, physician fees were not included. We also examined payer mix by evaluating the percentage of patients treated at each facility who had no ability to pay or had a limited ability to pay (ie, they were insured through Medicaid). This study was considered exempt per the institutional review boards at both universities.

Results

In the 1st 15 calendar years since the inception of the collaborative trauma program, there were 15,234 admissions to hospital A and 13,104 admissions to hospital B. The majority (greater than 86%) of trauma at both hospitals was blunt trauma. Although the 2 facilities are located in geographically different neighborhoods, they are only 2 miles apart with short interhospital drive times. Despite their proximity, differences in patient demographics are readily apparent (Table 1). Hospital B had significantly more penetrating trauma patients and more arrivals from the scene. Hospital B had significantly more patients with an Injury Severity Score (ISS) greater than 15 (29.8% vs 23.2%) and correspondingly a higher 15-year mortality rate (6.4% vs 5.2%). Furthermore, hospital B had a younger trauma patient population (38.8 vs 43.9 years) with a higher mean ISS (13.4 vs 11.7) and slightly lower mean Glasgow Coma Score (GCS) (13.3 vs 13.7) than hospital A (Table 2). The mean hospital length of stay at both hospitals was approx-

Table 2 Patient statistics, 1994–2008

Trauma patients	Hospital A	Hospital B
Age (mean ± SD, y)*	43.9 ± 25.1	38.8 ± 22.1¶
GCS (mean ± SD)†	13.7 ± 3.2	13.3 ± 3.8¶
ISS (mean ± SD)‡	11.7 ± 11.8	13.4 ± 13.9¶
Hospital length of stay (mean ± SD, d)§	5.1 ± 9.5	5.2 ± 8.9¶
ICU length of stay (mean ± SD, d)‖	1.2 ± 4.0	2.0 ± 4.3¶

SD, standard deviation; ICU, intensive care unit.

In the performance of statistical analyses, the values reflect only those patients in whom the data were available as follows: *age (data available for hospital A, 15,192 patients; hospital B, 12,987 patients), †GCS (data available for hospital A, 15,221 patients; hospital B, 13,065 patients), ‡ISS (data available for hospital A, 13,981 patients; hospital B, 11,951 patients), §hospital length of stay (data available for hospital A, 14,732 patients; hospital B, 12,421 patients), and ‖ICU length of stay (data available for hospital A, 15,231 patients; hospital B, 10,500 patients).

¶All values were significantly different ($P < .01$) between the 2 hospitals.

Table 3 Trauma team activations and posthospitalization disposition 1994–2008

	Hospital A	Hospital B
Traumas requiring trauma team activation	5,590	6,869
Trauma day	5,413	6,562*
Nontrauma day (%)	177 (1.2)	307 (2.3)*
Posthospitalization disposition		
Home	10,309 (68%)	9,562 (73%)
Rehabilitation facility	883	638
Subacute rehabilitation/nursing home	2,547	1,175
Other	1,495	1,643

*All values that were examined were significantly different ($P < .01$) between the 2 hospitals.

imately 5 days. As shown in Table 3, patient disposition after discharge from the hospital was to home in most cases, specifically 68% at hospital A and 73% at hospital B. The remaining patients were discharged to acute rehabilitation facilities, subacute rehabilitation facilities/nursing homes, and miscellaneous locations, such as prison.

A key measure of how well the joint trauma system functions is the number of trauma patients who required activation of the resource intensive trauma team on each hospital's nontrauma days. Members of the trauma team include the attending trauma surgeon, senior surgical resident, emergency department physician, emergency department resident, nurses, radiology technicians, and respiratory care personnel. If a substantial number of major trauma cases occurred at a facility on its nontrauma days, then a reasonable argument could be made that each hospital needs to operate independently and continuously as a trauma center. Over the past 15 years, however, only 177 (1.2%) patients admitted to hospital A and 307 (2.3%) patients admitted to hospital B required trauma team activation on their nontrauma days, respectively (Table 3). The higher numbers of trauma team activations on nontrauma days at hospital B are in part because of its geographic location; it has a higher percentage of penetrating trauma victims, resulting in more walk-ins and arrivals from the scene. We further evaluated the feasibility of a joint trauma system by examining the number of patients who had moderately high ISS but were treated on each center's nontrauma days; they may not have required trauma team activations. Only 120 patients were admitted to hospital A on its nontrauma days during this time period with ISS $\geq$10. Hospital B had 373 admissions with ISS $\geq$10 on its nontrauma days over the same 15 calendar year time period. The question therefore arises as to why any major trauma patients ended-up at a hospital on its nontrauma days. One explanation is that each hospital is responsible for its own walk-ins. Another explanation is that patient status can be upgraded to requiring trauma team activation upon evaluation in the emergency room regardless of the initial EMS encoding. Because injury severity can easily be underestimated at the scene or upon the initial evaluation in the hospital before imaging studies or therapeutic procedures, these numbers may not represent undertriage on initial EMS evaluation (ie, these patients did not meet criteria for evaluation at a trauma center). These data provide justification for in-house trauma attendings only on trauma days. The high percentage of blunt trauma patients and consequently less "walk-ins" facilitates home call for trauma attendings on a trauma center's nontrauma days, with the expectation that their services will be needed very infrequently.

Further support of the joint system's efficacy is provided by the trauma centers' readiness to support one another in times of need, whereby the nontrauma center of the day can promptly become activated. Over 2 calendar years, 2007 and 2008, there were 3 instances for a total time of about 9 hours where hospital A went on diversion. During this time period, 1 patient had to be diverted to hospital B. There were 5 instances between 2007 and 2008 in which hospital B went on diversion for a total of 33 hours. During this time period, 5 patients were diverted to hospital A. In both cases, the nontrauma facility of the day was rapidly activated, while the trauma center of the day resolved the problem that had resulted in trauma diversion. In none of these cases, was intensive care unit availability the limiting factor.

A 2nd key measure of the sustainability of this joint trauma system is its financial soundness. The average direct hospital cost per patient in 2008 was $13,897 for hospital A and $10,577 for hospital B. On average, indirect treatment costs were an additional $6,833 per case at hospital A and an additional $8,176 at hospital B in 2008. In 2008, the payer mix for inpatient treatment for injured patients at hospital A included 13% self-pay (charity/uninsured), 17% Medicaid, and 25% Medicare. The payer mix for hospital B for injured patients in 2008 included 19% self-pay (charity/uninsured), 15% Medicaid, and 22% Medicare. The mean hospital A charges per patient in 2008 were $61,103, not including professional fees. The mean hospital B charges per patient were $96,175 in 2008, again not including physician fees. This combination of costs, payer mix, and charges has allowed the trauma program at each medical center to remain financially solvent. The added financial benefits of joint trauma system oversight and outreach were not included in this calculation.

The 2 hospitals share outreach, injury prevention, and educational activities. For example, the Advanced Trauma Life Support provider course is provided at hospital A part of the year and at hospital B the other part of the year. Faculty and support staff from each institution are involved in each course, and the cost is shared. An annual Omaha trauma symposium is hosted jointly. The hospitals alternate the cost for this event. In addition, there are a variety of sites

that our outreach coordinators visit annually. By visiting different sites, efforts are not duplicated, and greater time can be spent at each visit and more referral hospitals can be covered. The programs also provide consultative visits to smaller facilities seeking to attain trauma credentialing. The 2 sites also participate in various injury-prevention activities. Both hospitals provide staff for the same event, if necessary; however, frequently, there is a division of labor so that more key events are covered. Finally, our joint trauma system's efficacy is validated by examination of the National Trauma Data Bank registry. In 2008, mortality at both hospitals was at about the 50th percentile in comparison with similar-sized level I trauma centers.[8]

Comments

In summary, the advantages of our collaborative trauma system are that it maintains the "prestige" and capabilities of comprehensive (comparable to ACS level I) trauma center designation at 2 otherwise competing medical schools/medical centers, shares the economic burden of caring for the uninsured and underinsured between 2 facilities, secures extramural oversight of morbidity/mortality and quality, facilitates cooperative educational and outreach ventures, and maintains a fiscally viable trauma program at each institution. Treatment at a level 1 trauma facility has been conclusively demonstrated to save lives in the care of injured patients. Mackenzie et al[9] in 2006 compared mortality at 18 level 1 trauma centers with 51 nontrauma centers in 14 states. They found that case-mix adjusted in-hospital mortality (7.6% vs 9.5%) and 1-year mortality (10.4% vs 13.8%) were significantly lower at level 1 trauma centers. Their data suggested that differences in mortality rates were primarily because of patients with more severe injuries. Specifically, there are an additional 3.4 lives saved per 100 trauma patients treated at a trauma center, with a mean of .7 years of life gained per patient, at an incremental cost per life-year gained of $36,319.[7] Our comprehensive joint trauma system provides this level of service.

Although care at designated trauma centers saves lives, the centers' ability to care for injured patients is hampered by the high cost of trauma care[7] coupled with the substantial proportion of patients who have a limited ability or inability to pay for their care. The cost of uncompensated care has been cited as the number one reason for trauma center closure.[4] In the United States, about 15% of the population has no health insurance and 12% of the population is covered by Medicaid.[10] Although there is some variation by state, hospital and physician reimbursement for care of Medicaid participants is far below that of private insurers. The level of reimbursement is often less than the hospital/physician cost of providing overall medical care.[11] More than one third of trauma patients at hospital A or B had either no ability to pay or had a limited ability to pay (ie, were covered by Medicaid). In contrast to the troubling findings of Dailey et al,[4] our joint trauma system generates revenue for each hospital. In evaluating our cost data, closure of the trauma program at either hospital would result in a net revenue loss at both hospitals for at least 2 reasons. First, services that support the trauma programs (eg, computed tomography services and personnel, respiratory care equipment and personnel, and emergency department personnel) would still be needed by the other resource intensive services of these tertiary care referral centers. Second, if either hospital closed, there would be a substantial increase in patients who could not pay or were able to minimally reimburse the remaining trauma center. These effects would at the very least substantially decrease the financial solvency of each institution and could render the remaining trauma center altogether insolvent. Our findings mirror a cost analysis performed in Philadelphia, PA, which allowed 2 separate hospital campuses to remain as functional trauma centers.[12] Finally, additional cost savings were realized in Omaha when the regional air ambulance service was formed in July 1997 by joining 2 competing services.

Another measure in evaluating a trauma center's financial soundness is the per patient index hospitalization charge. If per patient charges were significantly higher with a joint trauma system than in a single level I trauma center facility, then an argument could me made against a cooperative trauma program. However, as noted previously, the per patient charges at both of our institutions are comparable to those found by Mackenzie et al[7] in a study of the costs of patient care at trauma centers. They found that the mean index hospitalization charge, including physician fees, was $80,407 at trauma centers in 2005 US dollars. Our systems' per patient charges are comparable to the costs at trauma centers in other medical facilities, especially when considering that our numbers are in 2008 US dollars versus 2005 US dollars. Given the limited number of joint trauma systems, as listed later, data from Mackenzie et al likely, overwhelmingly if not exclusively, represent the charges of trauma care in single institutional trauma centers that are not a part of a joint system.

To cope with the economic turmoil, many trauma centers have closed or "de-designated," and a variety of alternate trauma system models have been developed. A joint trauma system was maintained in Erie, PA, for nearly 15 years, starting in 1983. Two hospitals cooperated to provide a regional trauma service (Tri-state Regional Trauma Center) whereby the trauma surgeons worked at the 2 facilities on alternating days.[13,14] A similar program was developed in Philadelphia, PA, where an integrated trauma program was developed at 2 separate campuses. The impetus for this was the merger of 2 academic-affiliated hospitals.[12] Before this merger, the 2 trauma centers were competitors; each hospital managed about 1,000 trauma patients annually before the merger. Another approach was pioneered in Illinois in which 2 separate medical facilities alternate trauma center status yearly.[15] They share a trauma director and trauma

nurse coordinators. Their trauma surgeons and trauma surgery residents go to the designated trauma center for the year. They found an eventual 95% appropriate triage to the trauma center of the year by EMS. The shared facilities are recognized as a state-verified level 1 trauma center. This concept of disparate health systems collaborating to care for injured patients gained attention in the public press in 2009 when the Cleveland Clinic and MetroHealth Systems teamed up to create a regional trauma network, the Northern Ohio Regional Trauma Network.[16] Our model of trauma care provides another cooperative way for institutions to provide trauma care.

Although the trauma surgeons and surgical residents on the trauma service at each trauma center in Omaha remain at their native institution, there is sharing of various subspecialists. For example, several neurosurgeons and hand surgeons are credentialed at both institutions. This is an added benefit of a joint system given the crisis level shortages of select specialties in various municipalities. Furthermore, in the event of situational crises (eg, power outage) at the trauma center of the day, the 2 hospitals have been able to rapidly activate the nontrauma center of the day, with a total of 8 instances in which trauma patients were diverted to the nontrauma center of the day.

The joint trauma program has been well received by surgical residents and trauma attending because there are days to decompress the service after busy trauma nights. Our model provides an interesting solution with regards to surgical residency work-hour restrictions as they relate to the trauma service. Senior-level residents are in-house only on a hospital's trauma day and are thereby more accessible on their nontrauma days. Although performed in a limited manner at both facilities presently, with the coming further resident work-hour restrictions, conceivably, the coverage on some of the trauma days at each facility could be performed more frequently by midlevel residents with an in-house attending. Given the additional costs that each institution would face in terms of hiring additional staff (physician extenders/physicians) to facilitate coverage of the trauma service with these work-hour restrictions, our model represents an innovative solution to the probable upcoming manpower shortfall. Given the limited overall trauma volume and the small number of severely injured patients seen at each center on its nontrauma nights and the additional cost to each facility to compensate trauma surgeons for nightly in-house coverage, in-house trauma surgeon coverage occurs only on trauma nights.

As noted by Trooskin et al[12] and Schiller and Anderson,[15] a key component in maintaining joint trauma center systems is a central administrative/oversight committee. This also facilitates ongoing quality improvement. As discussed earlier, our system has monthly joint peer-review meetings, morbidity and mortality conferences, and discussion of system-related issues. Furthermore, by performing joint peer review, there is an extramural method for evaluating each other's performance. Specifically, an attending physician from each hospital's trauma team attends the monthly peer-review meeting at the other hospital. Furthermore, difficult or unresolved cases are submitted to the trauma medical director of the opposite hospital for review. Additionally, there are joint educational and outreach programs. Finally, by having a collaborative trauma system, we have a better ability to evaluate system issues as they relate to EMS because the 2 hospitals constitute the only level 1 equivalent trauma center in our metropolitan area. Hence, suboptimal triage decisions can be examined for educational purposes and quality control. Finally, the joint trauma program has been well received by EMS, in part because the 3 days that one trauma center cares for injured patients and 4 days that the other trauma center cares for injured patients has not been changed since program inception.

A mass disaster event occurred in 2007, where a lone gunman opened fire at an Omaha shopping mall; this resulted in multiple casualties.[17] Both hospitals functioned together as trauma centers that day.

Conclusions

Competition in medicine is an important reason for the existence of multiple trauma centers and ambulance services or air medical services in a given area. Omaha requires only 1 active trauma center on any given day. The desire of each medical center to actively participate in trauma care has been used successfully to generate a cooperative model. This system not only has the economic advantage of dividing the number of days of trauma care and the sharing of various staff members among the 2 facilities but also the quality control advantage of oversight by otherwise separate entities. We believe that our model of trauma care could be used by others to defray the cost of trauma care and decrease trauma center closure. It would appear to be especially well suited for other moderate-sized cities with higher blunt trauma penetrance.

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