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Direct Transport to Tertiary Trauma Centers versus Transfer from Lower Level Facilities: Impact on Mortality and Morbidity among Patients with Major Trauma

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Background: **The purpose of the study was to compare the outcome of severely injured patients who were transported directly to a Level I, tertiary trauma center with those who were transferred after being first transported to less specialized hospitals.**

Methods: **The data were based on all patients treated at three tertiary trauma centers in Québec between April 1, 1993, and December 31, 1995. There were 1,608 patients (37%) transferred and 2,756 patients (63%) transported directly.**

Results: **The mean age of the patients was approximately 45 years, and more than 60% were males. The predominant mechanisms of injury were falls and motor vehicle crashes. The transfer and direct transport groups were similar with respect to age, gender, and mechanism of injury. Body regions injured were also similar with the exception of head or neck injuries (transfer, 56%; direct, 28%; $p < 0.0001$). The mean Injury Severity Score was 14, the mean Pre-Hospital Index score was 5.5, and the mean Revised Trauma Score was 7.5. The two groups were similar with respect to these injury severity measures.**

The primary outcome of interest was mortality described as overall death rate, death rate in the emergency room, and death rate after admission. Other outcomes studied were hospital length of stay and duration of treatment in an intensive care unit. When compared with the direct transport group, transferred patients were at increased risk for overall mortality (transfer, 8.9%; direct, 4.8%; odds ratio, 1.96; 95% confidence interval (CI) = 1.53–2.50), emergency room mortality (transfer, 3.4%; direct, 1.2%; odds ratio, 2.96; 95% CI = 1.90–4.6), and mortality after admission (transfer, 5.5%; direct, 3.6%; odds ratio, 1.57; 95% CI = 1.17–2.11). All of these differences were statistically significant ($p < 0.003$).

Stratified and multiple logistic regression analysis did not alter these results and failed to identify a patient subgroup for which transfer was associated with a reduced risk of mortality. After adjusting for patient age, Injury Severity Score, and presence of injuries to the head or neck and extremities, transferred patients stayed significantly longer in the hospital and the intensive care unit as indicated by the mean length of stay (transfer, 16.0 days; direct, 13.2 days; $p = 0.02$) and the mean intensive care unit stay (transfer, 2.0 days; direct, 0.95 days; $p = 0.001$).

Conclusion: **The results of this study have shown that transportation of severely injured patients from the scene directly to Level I trauma centers is associated with a reduction in mortality and morbidity. Further studies are required for the evaluation of transport protocols for rural trauma. Economic and cost-effectiveness considerations of patient triage are also essential.**

Key Words**: Trauma centers, Direct transport, Mortality, Hospital stay, Intensive care unit use.**

The implementation of regionalized trauma care systems involves at the minimum two essential components. First, the hospitals in the region should be classified according to the level of trauma care and expertise available. Within each region, hospitals are designated as Level I (tertiary), Level II (secondary), and Level III (primary) trauma centers. Level I trauma centers have continuous coverage by surgeons and a trauma team and are dedicated to trauma care training and research. Level II trauma centers have similar coverage as Level I centers with the exception that certain specialties may be available only on an "on-call" basis. In addition, Level II trauma centers are not involved in trauma care training or research. Finally Level III centers have trauma care specialties available only on an "on-call" basis and are not equipped to treat patients with severe life-threatening injuries.[1–3]

The second component of a regionalized trauma care system is the implementation of patient triage protocols by which severely injured patients are transported for definitive treatment at Level I centers. The data in the literature have shown that regionalization of trauma care reduces trauma-related mortality because the time interval between injury and definitive care is minimized and because patients are treated at highly specialized trauma centers.[4–7]

One of the questions that arises within regionalized trauma care systems is whether severely injured patients should be transported directly to Level I trauma centers while bypassing Level II or III facilities that are closer, or should these patients be transported first to nearby less specialized facilities for immediate care and stabilization and then be transferred to Level I centers? The benefit of the second approach

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would be reduced time between injury and in-hospital care. The disadvantage would be the fact that patients would not be initially assessed and treated by the staff of a Level I trauma center.

In Québec, a province of Canada with a population of approximately 8 million, trauma care regionalization was introduced in 1993 with the designation of four tertiary (Level I) and 33 secondary (Level II) centers. During the initial phase of regionalization, patients with severe injuries were transported to the nearest available hospital regardless of its designation. Agreements between hospitals, however, ensured that all tertiary trauma centers would receive all trauma patient transfers requested from less specialized hospitals. The criteria for designation and classification of trauma centers in our region were similar to those defined by the American College of Surgeons[3] and are as follows:

1. A tertiary (Level I) trauma center has 24-hour coverage by a surgeon, emergency physician, anesthetist, neurosurgeon, and nursing staff, as well as surgical and emergency residents. The staff of the tertiary trauma centers have extensive experience in the treatment of trauma. Tertiary trauma centers have identified trauma as the highest priority and have received additional funding for the maintenance of the trauma programs. In addition, tertiary trauma centers have university affiliations and are strongly involved in trauma research and training. In the current report, the terms "Level I" or "tertiary" trauma center will be used to refer to these hospitals.
2. Secondary (Level II) trauma centers have coverage by surgical and emergency room staff with other specialists being on-call. These centers have not received additional funding, do not have a formal trauma care program, and are not involved in trauma-related research or training.
3. Primary trauma centers and stabilization centers have only emergency room coverage. Surgical staff are available only on an on-call basis.

The currently implemented policy in Québec is that all patients with severe injuries who are initially transported to secondary, primary, or stabilization centers should be subsequently transferred to a tertiary trauma center. The purpose of the current study was to compare the outcome of trauma patients transported directly to the tertiary trauma centers with that of similar patients who were first transported to a secondary, primary, or stabilization center and subsequently transferred to the tertiary centers. The hypothesis tested in the current study is that patients with severe injuries who are first transported to nontertiary centers and then transferred to Level I trauma centers are at higher risk for mortality and morbidity compared with similar patients transported directly to the tertiary centers. The rationale for this hypothesis is based first on the fact that Level I, tertiary trauma centers in our system have the necessary staff, experience, and facilities to adequately treat patients with major trauma. Second, the process of transferring patients to Level I, tertiary centers from secondary, primary, or stabilization centers increases the delay to the high level of trauma care available at the tertiary trauma centers.

METHODS

This was an observational study based on patients who were included in the Québec Trauma Registry and in a larger study evaluating trauma care regionalization who were treated for injuries between April 1, 1993, and December 31, 1995. These patients were treated at the three Level I trauma centers that were operational during the study period. Two of these trauma centers, The Montreal General Hospital and Sacré Coeur Hospital, are in Montréal, and the third, Enfant-Jésus Hospital, is in Québec City. To be included in the study, the patients had to fulfill the following criteria: (1) they were injured within the city limits; (2) they were transported to the hospital by the local emergency medical system; and (3) they were alive upon arrival at the hospital. Additionally, one of the following had to apply: (1) death as a result of the injury; (2) hospital stay of more than 3 days; or (3) admission to an intensive care unit.

The outcomes of interest were mortality, length of hospital stay, and length of intensive care unit stay. Patients were classified into two groups according to their method of arrival at the tertiary trauma center: direct or transfer.

Data on patient age, mechanism of injury, Abbreviated Injury Scale (AIS) score (1990 version),[8] Injury Severity Score (ISS)[9], Pre-Hospital Index[10,11] score, and the Revised Trauma Score[12] were also collected. The AIS score and the ISS were determined and calculated after chart review by trained medical archivists. The Pre-Hospital Index score and the Revised Trauma Score were calculated on the basis of data obtained at the emergency room.

For continuous variables, the two patient groups were compared using the independent sample Student's t test, and for categorical variables, the χ^2 statistic was used. The odds ratio was used as an estimate of the relative risk for dying, which was adjusted for the effect of potential confounders with multiple logistic regression. Adjusted differences between the two groups with respect to duration of hospital and intensive care unit stay were estimated using multiple linear regression.

To evaluate whether the association between method of hospital arrival and mortality was modified by injury severity, presence of injuries to the head or neck, or severity of head trauma, two stratified analyses were performed. The first stratification involved two factors: the presence or absence of injuries to the head or neck, and the ISS level. The second stratification was based on the severity of head trauma measured by the Abbreviated Injury Scale.

RESULTS

A total of 4,364 patients were included in the study, of which 2,756 (63%) were transported directly to the Level I trauma centers and 1,608 (37%) were transferred from another hospital. Of the total transfers, there were 437 (27%) from a secondary center and 1,171 (73%) from primary hospitals. The data summarized in Table 1 show that the mean age of the patients in the direct group was slightly higher compared with that in the transfer group. The proportion of male patients in the direct group was slightly lower than that in the

TABLE 1. Patient characteristics and injury profile

Parameter	Group: Transfer	Group: Direct
Number	1,608	2,756
Mean age in years (SD)	42 (21)	48 (23)
Gender, n (%)		
Male	1,136 (71)	1,685 (61)
Female	472 (29)	1,071 (39)
Mechanism of injury n (%)		
Motor vehicle crash	706 (44)	967 (36)
Falls	551 (34)	1,169 (38)
Gunshots	36 (2)	53 (2)
Stabbings	145 (9)	313 (11)
Blunt object	109 (7)	225 (8)
Other	61 (4)	129 (5)
Body region, n (%)		
Head or neck	900 (56)	764 (28)
Face	569 (35)	678 (25)
Thorax	359 (22)	438 (16)
Abdomen	232 (14)	330 (12)
Extremities	978 (61)	2,048 (74)
Mean (SD) Injury Severity Score	14.4 (10.7)	14.1 (9.6)
Mean (SD) Revised Trauma Score	7.2 (1.1)	7.6 (0.8)
Mean (SD) Pre-Hospital Index score	6.0 (3.0)	5.4 (2.6)

transfer groups. Both of these differences were statistically significant ($p < 0.001$), but their clinical importance is moderate. The distribution of mechanism of injury was similar for the two groups. The incidence of head or neck injuries in the direct group was 28% compared with 56% in the transfer group. This difference was statistically ($p < 0.001$) and clinically significant. The incidence of injury to the other body regions was similar for the two groups. For both groups, the mean Injury Severity Score was approximately 14, the mean Revised Trauma Score was approximately 7, and the mean Pre-Hospital Index score was approximately 5.5. The distribution of these injury severity measures was similar for the two groups.

Table 2 summarizes the mortality in the two groups. These data show that the overall mortality in the direct group was 4.8%, which was significantly lower than the 8.9% rate observed in the transfer group ($p = 0.001$). The odds ratio (95% confidence interval (CI)) for dying associated with being in the transfer group was 1.96 (1.53–2.50). The difference between the two groups was more noticeable for emergency room mortality, for which the rate in the direct group was 1.2% compared with 3.4% in the transfer group ($p = 0.001$). The odds ratio (95% CI) for emergency room mortality associated with being transferred was 2.96 (1.9–4.6). A somewhat smaller but nonetheless significant ($p = 0.003$) difference was observed for death rates after admission, which were 3.6 and 5.5% in the direct and transfer groups, respectively. The odds ratio (95% CI) for mortality after admission was 1.57 (1.17–2.11).

TABLE 2. Mortality by trauma center transport

Patient Group	Mortality, n (%): Emergency Room	Admission	Total
Direct	32 (1.2)	99 (3.6)	131 (4.8)
Transfer	54 (3.4)	89 (5.5)	143 (8.9)
Odds ratio (95% CI)	2.96 (1.90–4.60)	1.57 (1.17–2.11)	1.96 (1.53–2.50)
p^a	0.001	0.003	0.001

[a] Based on χ^2 statistic.

TABLE 3. Logistic regression analysis for all mortality

Variable	Parameter Estimate (SE)	Odds Ratio (95% CI)	p
Transport (transport vs. direct)	0.45 (0.15)	1.57 (1.17–2.08)	0.02
Injury Severity Score	0.08 (0.006)	1.08 (1.07–1.09)	0.001
Age	0.02 (0.003)	1.02 (1.01–1.03)	0.001
Head or neck injury	0.57 (0.16)	1.76 (1.28–2.43)	0.0005
Extremity injury	0.51 (0.14)	0.60 (0.46–0.79)	0.0004

Table 3 shows the results of the logistic regression analysis for overall mortality. The final model shown in the table was selected by a stepwise process from a model that included all the variables listed in Table 1. This model showed that after adjusting for the effect of Injury Severity Score, patient age, and the presence of head or neck and extremity injuries, the method of transport remained statistically significantly associated with mortality ($p = 0.02$). The adjusted relative odds (95% CI) for mortality associated with being transferred compared with direct transport to the trauma center was 1.57 (1.17–2.08).

Head or neck trauma is associated with a high risk for mortality. For this reason and because of the significant difference in the incidence of head or neck injuries between the two patient groups, the analyses were stratified for the presence of head or neck trauma. To introduce further control and to describe the results in a more clinically meaningful manner, the analyses were further stratified according to overall injury severity as measured by the ISS into mild (ISS = 1–12), moderate (ISS = 13–24), and severe (ISS = 25–75).

The results of the stratified analyses are summarized in Table 4 and Figure 1. These data show that for patients with head or neck injuries, the odds of dying among the transferred patients was elevated in the subgroups of patients with mild and moderate overall injury severity. For these two subgroups, the odds ratios were 2.3 and 1.6, respectively, which only approached statistical significance but are clinically noteworthy. The mortality rate for patients with head or neck injuries and severe overall injury severity was comparatively very high (23.2%) and was not different for the direct and transfer groups.

For patients without head or neck injuries, the odds of dying associated with being transferred was higher for all strata of overall injury severity. Specifically, the estimated odds ratios were 1.5 for the mild, 3.1 for the moderate, and 2.6 for the severe overall injury severity strata. These estimates are all clinically important, although only that for the moderate subgroup was statistically significant ($p = 0.03$), whereas that for the severe subgroup approached statistical significance ($p = 0.08$).

The results of logistic regression analysis stratified by the presence of head or neck injuries are summarized in Table 5.

TABLE 4. Mortality by trauma center transport stratified by ISS and presence of head or neck injury

Body Region	ISS	Transport	Number of Patients	Mortality, n (%)	Odds ratio (95% CI)	p^a
Head or neck	1–12	Direct	312	5 (1.6)	2.3 (0.76–6.92)	0.11
		Transfer	257	9 (3.5)		
	13–24	Direct	247	18 (7.3)	1.6 (0.88–2.87)	0.08
		Transfer	333	37 (11.1)		
	25–75	Direct	194	45 (23.2)	1.00 (0.66–1.54)	0.54
		Transfer	306	71 (23.2)		
Other	1–12	Direct	1,400	21 (1.5)	1.5 (0.76–2.98)	0.16
		Transfer	637	14 (2.2)		
	13–24	Direct	227	10 (4.4)	3.1 (1.13–8.63)	0.03
		Transfer	56	7 (12.5)		
	25–75	Direct	367	32 (8.8)	2.6 (0.91–7.35)	0.08
		Transfer	25	5 (20.0)		

[a] Based on χ^2 test.

These data show that after adjusting for the effects of the overall ISS, patient age, and the presence of extremity injury, the patients with head or neck injuries who were transferred had an elevated odds ratio of dying that approached statistical significance (adjusted odds ratio = 1.29; 95% CI = 0.93–1.18; p = 0.14).

For patients without head or neck injuries, the odds ratio associated with being transferred was 2.58 (95% CI = 1.54–4.32), which remained highly statistically significant (p = 0.0003) after adjusting for overall injury severity, patient age, and the presence of extremity injuries. The associations for mortality in the emergency room and mortality after admission produced by stratified analyses and logistic regression were similar in magnitude and direction as that for overall mortality (data not shown).

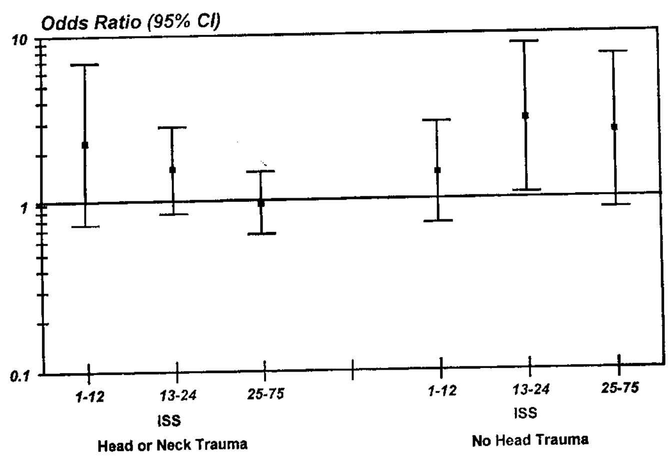

FIG 1. Odds ratio for mortality (transfer vs. direct transport) by head injury and ISS.

TABLE 5. Stratified logistic regression analysis for all mortality

Body Region	Variable	Odds Ratio (95% CI)	p^a
Head or neck	Transport (transfer vs. direct)	1.29 (0.93–1.81)	0.14
	Injury Severity Score	1.08 (1.07–1.10)	0.001
	Age	1.01 (1.00–1.02)	0.0002
	Extremities	0.50 (0.36–0.72)	0.001
Other	Transport (transfer vs. direct)	2.58 (1.54–4.32)	0.0003
	Injury Severity Score	1.09 (1.07–1.12)	0.0001
	Age	1.03 (1.02–1.04)	0.0001
	Extremities	0.80 (0.46–1.39)	0.44

[a] Based on the χ^2 statistic.

The results of the association between mortality and method of transport stratified by head injury severity are summarized in Table 6 and Figure 2. These data show that for patients without a head injury, being transferred to the tertiary trauma center was associated with a statistically significant 74% increase in the odds of dying (p = 0.0001). For patients with minor head trauma, there was an overall low mortality, which was not different between the two groups. For patients with moderate head injuries (AIS score = 3), the mortality among patients who were transferred was significantly higher compared with the patients transported directly to the trauma centers (p = 0.05). For this patient group, the odds ratio (95% CI) was 2.69 (1.00–7.93). For patients with severe head injuries, the association between odds of dying and method of transport to the tertiary center was statistically significant, as shown by the odds ratio (95% CI) of 1.59 (1.03–2.43) (p = 0.02). The above associations did not change when multiple logistic regression was used to adjust for patient age and overall ISS.

The results in Table 7 show that patients in the direct transport group had a mean hospital stay of 13.6 days compared with 15.5 days for those in the transfer group. The mean number of days in an intensive care unit was 4.8 in the direct group and 6.5 in the transfer group. The differences between the two patient groups were statistically significant (p = 0.0001).

Multiple linear regression was used to evaluate the differences in hospital and intensive care unit stay between the two

TABLE 6. Mortality by trauma center transport stratified by severity of head injury

Head Injury AIS Score	Transport	Number of Patients	Mortality n (%)	Odds Ratio (95% CI)	p^a
No head injury	Direct	1,924	71 (3.6)	1.74 (1.26–2.53)	0.001
	Transfer	948	61 (6.4)		
1–2	Direct	370	16 (4.3)	1.09 (0.46–2.60)	0.50
	Transfer	170	8 (4.7)		
3	Direct	107	5 (4.7)	2.69 (1.00–7.93)	0.05
	Transfer	103	12 (11.7)		
4–5	Direct	359	39 (10.9)	1.59 (1.03–2.43)	0.02
	Transfer	383	62 (16.2)		

[a] Based on χ^2 test.

groups after adjusting for Injury Severity Score, patient age, and the presence of injury to the head or neck and the extremities. The results of these analyses, which are presented in Table 8, show that the adjusted mean for hospital stay in the direct group was 13.2 days compared with 16.0 days for the transfer group ($p = 0.02$). The adjusted mean stay in an intensive care unit was 0.95 and 2.02 days in the direct and transfer groups, respectively ($p = 0.001$).

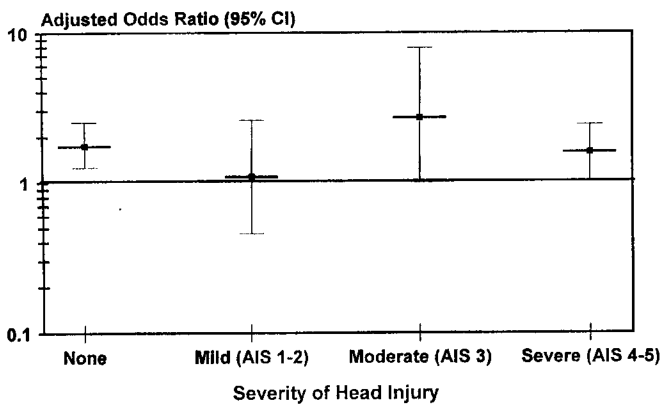

FIG 2. Adjusted odds ratio for mortality (transfer vs. direct transport) by severity of head injury.

TABLE 7. Hospital length of stay and intensive care unit stay

Transport	Mean Days (SD)	
	Hospital	Intensive Care
Direct	13.6 (23.9)	4.8 (8.1)
Transfer	15.5 (22.1)	6.5 (9.3)
p^a	0.001	0.001

[a] Based on Student's t test for independent samples.

TABLE 8. Adjusted differences for hospital and intensive care unit stay

Transport	Adjusted Mean Days[a] (SE)	
	Hospital	Intensive Care
Direct	13.19 (0.44)	0.95 (0.09)
Transfer	16.00 (0.59)	2.02 (0.12)
p^b	0.02	0.001

[a] Adjusted for ISS, age, head or neck injuries, and extremity injuries.

[b] Based on multiple linear regression.

DISCUSSION

The results of the current study have shown that in our system, trauma patients transferred to a tertiary, Level I trauma center after first being transported from the scene to a secondary or primary trauma center were at increased risk for mortality. After adjusting for injury severity, patient age, and the presence of injuries to the head, neck, or extremities, the transferred patients had a significant increase in the risk of dying. More specifically, these patients had a 57% adjusted increase in the odds of dying.

The most probable explanation of this observation is that Level I trauma centers have the expertise and availability of staff and technology required to treat patients with life-threatening injuries. These attributes are not as developed in secondary trauma centers and are nonexistent in other hospitals. Several authors have reported important and significant differences with respect to reduced mortality for trauma patients treated at Level I centers compared with other hospitals.[7,13,14]

The effect of method of arrival to the Level I centers on patient outcome is even more likely attributable to differences in quality of trauma care between Level I, tertiary trauma centers and other hospitals in our study. This is because in our system only the four tertiary centers have received additional financial support for the development and operation of their trauma care programs.

Another possible explanation of the observed differences in mortality rates is that the transferred patients were more severely injured compared with those transported directly. However, the data on three measures on injury severity including two physiologic indices showed no differences between the two groups.

The similarity of the two groups in the overall injury severity and the lack of difference with respect to two physiologic measures of injury severity are important. The similarity with respect to the ISS indicates that the two groups suffered anatomic damage that presented the same level of risk for mortality. The similarity with respect to the two physiologic injury severity indices indicates that the physiologic state and level of deterioration at the time of arrival of the patients at the first hospital was the same for the two groups. In view of these similarities, the observed difference in patient outcomes between the two groups is not likely the result of differences in injury severity. Furthermore, the similarity of the two groups with respect to the physiologic state upon arrival at the first receiving hospital would suggest that differences in the prehospital course, including type of on-scene care and prehospital time, could not sufficiently explain the difference in patient outcomes. This, in combination with the more profound between-group difference with respect to emergency room mortality, would further suggest that the level of care at the nontertiary hospitals was inferior and ineffective at stabilizing patients with severe injuries.

At this point, a discussion of the validity of the injury severity scales used is warranted. In the present study, the ISS was used as the anatomic measure of injury severity. Despite its limitations, the ISS remains the best available and most widely used measure of anatomic injury. Although other measures of injury severity have been developed more recently, the data evaluating their validity and demonstrating their superior accuracy in comparison with the ISS are limited and inconclusive. Our decision to use the ISS as the anatomic measure of injury severity was based on these facts and on the need to remain comparable with other similar studies in the literature.

To compensate for any loss of validity in accurately controlling for injury severity by using the ISS, we adjusted our analyses for other indices of injury severity, specifically body regions injured and mechanism of injury. These variables were in fact significantly and independently associated with the risk of mortality even after adjusting for the effect of ISS.

The physiologic measures of injury severity used in the present study were the Revised Trauma Score and the Pre-Hospital Index score. These two measures are based on similar parameters and have been shown to have a high predictive validity for mortality among trauma patients. When entered in the multiple logistic regression models that included the ISS, patient age, and body regions injured, however, these measures did not contribute significantly to the accuracy of predicting mortality and were therefore not included in the final models.

In view of the above discussion, we are confident that the best possible adjustment for injury severity was used in our study. This adjustment was based on all known predictors of outcome in trauma patients and may be limited only by our lack of understanding of the association between injury severity and the related mortality and morbidity.

In addition to the difference with respect to the quality of care between the tertiary and the nontertiary trauma hospitals, another factor that may contribute to the observed differences between directly transported and transferred patients is the transfer process itself. The transfer process may affect the outcome of trauma patients by two possible means: first, through increasing the delay to definitive in-hospital care, and second, through adverse effects of the transfer.

Time to definitive in-hospital care, or prehospital time, comprises the time elapsed between the time of the injury and arrival at the hospital. For patients transferred from other hospitals to tertiary trauma centers, time to definitive in-hospital care may also include another component. This second component would be the time elapsed between arrival of the patient at the first receiving hospital and the time that the patient reached the tertiary center. Inclusion of this second component in the calculation of prehospital time depends on whether treatment at the first receiving, nontertiary center is considered to be definitive trauma care. If we were to adopt a policy of first transporting severely injured patients to the nearest available acute care hospital, with even the lowest possible trauma center designation, and then transferring them to tertiary centers, we accept the assumption that definitive trauma care begins at the first receiving hospital regardless of its designation. Alternatively, a policy of transporting all severely injured patients directly to tertiary trauma centers is compatible with the assumption that definitive trauma care begins only when the patient is treated at the tertiary trauma center.

The present study was challenging the assumption that definitive care begins when the patient arrives at the first receiving hospital regardless of the level of trauma care available. The relevant parameter in testing this assumption is the time between the injury and the patient's arrival at the first receiving hospital. The mean time between injury and arrival at the first hospital was 32.8 minutes for the transferred and 42.6 minutes for the direct transport patients. This difference was statistically significant ($p < 0.001$) and clinically important. To calculate this interval, the time of injury was approximated from the time that the call requesting assistance was received at the local emergency medical service. The mean time between arrival at the first receiving hospital and transfer to the tertiary center was approximately 12 hours.

These results show that the prehospital time was significantly longer by more than 10 minutes for the patients transported directly to the trauma center. Prolonged prehospital time, therefore, is not a likely explanation of the observed difference in patient outcome between these two patient groups. In fact, if prolonged prehospital time was associated with an increased risk of mortality or longer hospital stay, the directly transported patients would be at a disadvantage. Our results show that despite longer prehospital delays, the directly transported patients had a decreased risk of mortality and shorter hospital stay. This finding strongly suggests that any negative effects introduced by the longer prehospital times are compensated for by the quality of care at the tertiary centers.

The possibility that the transfer process itself increases the risk of mortality should also be considered. The potential negative effect of the transfer was assessed in one study and was shown to be low and noncontributing to the risk of mortality.[15] Being transferred was associated with a 2-fold increase in the risk of dying for patients with head trauma and minor overall injury severity. Although this increased risk was clinically important, it was not statistically significant because of low power attributable to the small number of deaths in this subgroup. For patients with head injuries and moderate overall injury severity, being transferred was associated with a 60% increase in the risk of mortality, which nevertheless only approached statistical significance. This was also attributable to the relatively small number of deaths in the group. The mortality rates of the directly transported and transferred patients with severe injuries and head trauma were not different between the two groups. This lack of effect is quite likely the result of the high mortality rate that was observed for these patient groups, which could not be affected by differences in hospital care. For patients without head trauma, there was an increased risk in mortality associated with being transferred for all ISS strata. The most important effect, however, was observed for patients with moderate and high injury severity.

Stratification of patients with and without head or neck injuries by the overall injury severity was used in the analysis because total injury severity is independently associated with the risk of mortality after adjusting for the presence of injuries to the head or neck. Furthermore, the results of the logistic regression analyses summarized in Table 6 show that, even after stratification of the study sample according to the presence of head or neck injuries, the overall ISS remained a highly significant predictor of mortality. Finally, from a clinical point of view, the presence of head or neck injuries would certainly indicate a high-risk patient. It is the total sum of the severity of all injuries, however, that defines the risk of mortality for a particular patient.

Patients with head trauma are an important group because of the acute nature of the injury, which requires definitive care with minimal delay. The hypothesis tested in our study was that patients with severe head injuries would benefit by being first transported to a nontertiary center for stabilization and subsequently transferred to a tertiary center for treatment. The data from our study did not support this hypothesis, and furthermore, they demonstrated that even for this patient group, being transported directly to the tertiary trauma center was associated with a significant reduction in the risk of mortality.

The results of our study suggest that the presence of a trauma team and neurologic staff with expertise in neurotrauma contributes to a significant reduction in mortality among patients with severe head trauma who are transported directly to the tertiary trauma centers. Our results further suggest that the lack of appropriate expertise at the nontertiary trauma centers and the prolonged delay to care at a tertiary trauma center increase the risk of mortality among patients with severe head trauma who are transported first to these hospitals and subsequently transferred to the tertiary centers.

The results of our study suggest that patients with moderate to severe injuries should be transported from the scene directly to a Level I trauma center. What is important is that for none of the subgroups analyzed was direct transport associated with an increase in the risk of mortality, despite the longer prehospital time. This would argue against the immediate transport of trauma patients from the site to less specialized but closer hospitals. Sloan has also shown that the increased prehospital time introduced by bypassing non-Level I hospitals did not cause an increase in the risk of mortality among patients with severe trauma.[16] This is in agreement with our findings and would suggest that the effect of increases in prehospital time is compensated for by the quality of care at tertiary centers.

The results presented here and in other studies should be interpreted with caution if the interhospital transfers are not between urban hospitals. More specifically, our data and those in the literature would favor bypassing non-Level I hospitals when the injury has occurred within the urban limits. Extrapolation of these results to rural trauma, where the injury occurs in locations that are at considerable distances from tertiary, regional Level I trauma centers, is not appropriate. Further studies are required to define safe transfer protocols for patients injured in rural locations. This problem has been recognized by other researchers[14] but has not been conclusively addressed.

With respect to length of stay in the hospital and the intensive care unit, both the crude and adjusted analysis showed that directly transported patients had significantly shorter hospital and intensive care stay. These data show that the adjusted mean difference in hospital stay between the directly transported and the transferred patients was approximately 3 days. Extrapolation of these results to the total cohort of patients in the study would show that for the time period covered, the total hospital stay would be reduced by an estimated 4,500 patient days. The 95% confidence intervals for this estimate is between 1,260 and 7,740. The data on intensive care unit stay show that the adjusted mean difference between the two patient groups was approximately 1 day. Similar extrapolation would produce estimates of a reduction in the total intensive care unit stay of approximately 1,726 days, with 95% confidence intervals between 1,360 and 2,090.

The target population of the present study was that of patients with major trauma who were treated at Level I, tertiary trauma centers. The severity of the injuries sustained by these patients indicated that treatment at a tertiary trauma center was necessary. The present study challenged the hypothesis that for these patients initial transport from the scene to a more proximal, nontertiary trauma center would improve patient outcome compared with direct transport to the tertiary center with bypassing of the nontertiary institutions. To test this hypothesis, we did not consider the outcome of patients who were transported, treated, and discharged from the nontertiary centers. Consequently, we did not evaluate the survival or mortality rates of patients treated at these institutions. The rationale for this exclusion was based first on our choice of the target population, which was that of patients treated at the tertiary trauma centers. Second, we were interested in evaluating the effectiveness of two trauma patient management algorithms, one involving transport to the nearest acute care hospital followed by transfer to the tertiary trauma center, and the other involving direct transport to the tertiary center.

CONCLUSION

The results of this study support the direct transport of severely injured patients to tertiary or Level I trauma centers without treatment or attempts at stabilization at other facilities. Further research is required to determine whether this conclusion should be generalized to cases of rural trauma. Identification of patient subgroups for which non-Level I hospitals could provide adequate and immediate care should be pursued to prevent excessive triage. Cost-effectiveness evaluation should be conducted to ensure that direct transport of patients with severe trauma will result in efficient use of the scarce health care resources.

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DISCUSSION

Dr. C. Gene Cayten (Bronx, New York): Dr. Sampalis and his colleagues are to be congratulated for attempting to show us the value of Level I trauma centers compared with Level II and Level III centers. Lest we feel than this issue has been laid to rest, the issue of cost at Level I trauma centers is now being raised.

In April, Goldfarb et al. in *Health Services Research* used administrative data sets to show that with crude controls for case mix level, Level I trauma is much more costly than Level II and Level III. They concluded by saying that states should limit the number of trauma centers designated or reconsider the requirements placed on these centers.

I raise four issues. By studying only transferred Level II and Level III center patients, there may be selection bias not sufficiently controlled for by using ISS. To fairly attribute increased survival to Level I centers, we need to know the outcome of patients treated at Level II and Level III centers and not transferred.

Second, the authors do not rule out the threat to the validity of their conclusions that emergency medical services (EMS) differences may have contributed to the poor outcome of the transfer group. Did helicopters play a role? In 1987, Baxt found that for patients with severe brain injuries, helicopter transport resulted in increased survival compared with land advanced life support transport.

Also, Dr. Sampalis, in your own paper presented at AAST in Philadelphia, you indicated that physicians were used in Montreal for some prehospital care, and that in doing so introduced considerable variability into that level of care. Could this difference and differences in prehospital times have had an effect on your study?

Third, the answers to these first two issues assume less importance if I were comfortable with the methods used to control for case mix. However, I am not. The authors have attempted to control for severity using the elements of the Trauma and Injury Severity Score method, although numerous investigators, including Copes, Champion, Rutledge, Hannan, and myself, have documented limitations to ISS and have suggested improvements, such as the American College of Surgeons' Committee on Trauma (ASCOT), modifications thereof, and neural network models. Could poor care have inflated the AIS score and hence ISS for some patients, as recently suggested by Rutledge?

As a fourth issue, 10 years ago at Cook County Hospital, the Cook County Hospital group found that patients with subdural hematoma and a lucid period after injury had a 65% mortality among transferred patients versus a 25% mortality for those admitted directly to trauma centers. Did you look at this group of patients? I suggest that we need further studies to know more specifically which patients will benefit from direct transfer to Level I trauma centers.

In conclusion, although we know that randomized control studies to prove the value of Level I trauma centers are not possible or even ethical, we need to use as much methodological rigor as possible and be very cautious in our interpretation of results from descriptive studies.

I would like to thank the Association and the Program Committee for the opportunity to discuss this paper.

Dr. James G. Hinsdale (San Jose, California): I, too, enjoyed the paper. As many of you know, managed care is entrenched in the state of California, and the managed-care lobby is advocating strenuously to the EMS agencies that we have a wholesale expansion of hospitals to become Level III trauma centers. The idea would be that they would stabilize and send the toughest cases to the Level I centers, and you might suspect that cost would be a factor for this.

In my county alone, there are 13 hospitals well served by three Level I centers. Now they've invited all the hospitals to become Level III centers. We think this will obviously take us back to the dark ages before we developed a trauma system and American College of Surgeons field criteria for triage.

I think this paper is very important politically to tell our elected officials, at least from a mortality standpoint, that this is not the right direction to start heading for now. I think if you look at your data with respect to morbidity, you could probably come back with another paper with similar provocative results. I further suggest that any time a managed-care organization approaches your county to help in improving trauma care, take a deep breath and watch out.

Dr. James M. Betts (Oakland, California): Who in the field made the determination as to where the patient was going to be transported, and how did they make that determination?

Dr. Paul E. Collicott (Lincoln, Nebraska): I know that I am just a "country surgeon," but I have had the opportunity to travel around the United States reviewing Level I and Level II trauma centers for the American College of Surgeons' Verification/Consultation Program. I believe that it is dangerous for us to say that trauma patients should only be transferred to Level I facilities. We should ask our Canadian colleagues whether they use the Level I, II, III classification system that we so routinely use here in the United States, particularly if this paper is to be published. In my visits here in the U.S., I have seen no difference in the quality of care between Level I and Level II institutions.

I am very fearful that advocating just Level I facilities as the only place to transfer trauma patients conveys the wrong message. I would prefer that the term "trauma centers" be used rather than "Level I." I think everyone in this room would agree that transferring a patient from a less specialized facility to another is entirely appropriate, but to say that the patient should only be transferred to a Level I trauma facility is not appropriate.

I would like to ask the authors if there was any difference between neurosurgical coverage at the outlying hospitals as opposed to the receiving hospitals? Also, was there any difference regarding Advanced Trauma Life Support training or board certification?

I enjoyed the paper very much and thank the association for the privilege of the floor.

Dr. John S. Sampalis (closing): I would like to thank Dr. Cayten for reading this paper and all the discussants for the very interesting questions, beginning with Dr. Cayten's comments.

I don't think that EMS differences would have contributed to the observed results of this study. The EMS systems were consistent throughout the time. In fact, I did look but did not present the results at the type of care that the patients received before coming to the first receiving centers, and they were not different, with respect to both the presence of physicians and the prehospital times.

I'm hesitant to agree that using ISS and age and body region does not provide us with enough control. I think it provides us with probably the best kind of control we could have right now. We do not look at other methods, namely the ASCOT, and perhaps this is something we should do. But I recall reading at least one study in which control with the ASCOT did not really change the way the results were adjusted for. However, I think we should look at it sometime.

I think the final comment by Dr. Cayten is certainly in agreement with one of our conclusions, in which we were saying that we now need to go and identify potential subgroups of patients that may benefit or may not benefit by being first transported directly to a Level I trauma center. In other words, I could not disagree that by implementing a very general protocol of taking all patients to Level I trauma centers, we will increase the costs in these places. I think what this study is showing is that we are providing better care, and then we need to go further and identify which patients should be taken directly and which patients could be treated adequately at less specialized centers.

I totally agree with Dr. Hinsdale's conclusions that we will need to look at morbidity and to keep away from people who are going to try and tell us to introduce managed care in our facilities.

Dr. Betts' question is a very good one, too. The determination of where the patient went was done by the EMS personnel, either the emergency medical technician or the physician, and they went to the nearest hospital that was a designated hospital at that time, either Level I, II, or primary care center.

And finally, Dr. Collicott, I also agree with you that perhaps classifying hospitals as Level I or Level II may not be appropriate today, and in our system we do in fact use the terms "tertiary," "secondary," "primary," or "stabilization" centers.

With respect to the differences of a tertiary and secondary center in our system, I think they are substantial. In our system, only tertiary centers have received additional funding for the support of trauma care. No other hospitals have received such funding. Furthermore, the tertiary centers are the ones that are involved in training of residents and have staff that are totally committed to the treatment of trauma patients. The other hospitals do not. So I think that at least in our system, these differences are substantial.

I'd like to thank everyone for their questions and the opportunity to present this work. Thank you.