0022-5282/86/2611-0963$02.00/0
THE JOURNAL OF TRAUMA
Vol. 26, No. 11
Printed in U.S.A.

Field Triage for On-scene Helicopter Transport

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This prospective study evaluated the use of basic vital signs, two mechanisms of injury, and time-distance factors as field triage criteria for on-scene helicopter transport of 130 patients to a trauma center serving a rural area. The vital signs criteria included any one or more of the following: a) level of consciousness (LOC) ≤ unresponsive to verbal stimulation; b) respiration rate (RR) ≤ 10 or ≥ 30; c) systolic blood pressure (BP) ≤ 90; d) pulse (P) ≤ 60 or ≥ 120. The flight crew recorded vital signs taken by the first responder capable of basic assessment. Entrapment and associated fatalities in motor vehicular accidents were recorded and flight logistics were examined. The presence of one or more abnormal signs identified a group of seriously injured trauma patients (mean Injury Severity Score = 29.1) with 24% mortality compared to a predicted mortality of 32% ($p < 0.02$). Unresponsiveness to verbal stimulation in the field was the single most predictive criterion, yielding sensitivity of 93% and specificity of 85%. Time-distance criteria were helpful to determine helicopter use.

The first responder at the scene of an accident must be able to identify the patients for whom helicopter transport to a trauma center is indicated. Several investigators have recently reported on triage tools that have been used in the field to identify trauma center candidates (6–9, 13–15, 18). Champion et al. have developed a formula which combines the Injury Severity Score (ISS), as described by Baker (2), with an admitting Trauma Score (TS) and age, resulting in a calculated probability of survival (TRISS) to use as a triage "endpoint" (5).

Although numerous reports have described on-scene helicopter transport of trauma patients (3, 4, 10–12, 16, 17, 19, 20), no studies have examined prehospital triage in an on-scene helicopter transport system functioning in a moderately rural area. This prospective study evaluates the use of basic vital signs, two mechanisms of injury, and time-distance factors as field triage criteria for on-scene helicopter transport to a trauma center serving a rural area.

MATERIALS AND METHODS

Sample. The study was conducted in an eastern Pennsylvania state-designated trauma center serving a population of 1.5 million extending over ten counties. The trauma center is supported by a hospital-based helicopter program (MedEvac) which has completed more than 1,000 on-scene helicopter transport missions since its inception. Initially included in the prospective study group were 143 trauma patients transported from the scene by helicopter over a 7-month period. Thirteen patients were considered dead at the scene before transport because they showed no vital signs when first assessed. However CPR had been initiated in the field and was continued until arrival at the trauma center. These 13 patients were pronounced dead on arrival and were excluded from the study, leaving a study population of 130.

Data Collection. In a massive educational effort extending through 3 years preceding this study, more than 24,000 prehospital first responders and command physicians were taught field triage criteria for the trauma center and for helicopter transport based on simple vital signs, mechanisms of injury, and time-distance factors (Fig. 1). Land rather than air transport was used if the patient was ready to move at the time the helicopter was being considered and if the estimated ground transport time to the trauma center was 20 minutes or less. For this study, which included only air-transported patients, the flight crew (nurse and paramedic) recorded the first available vital signs taken by the first responder capable of basic assessment. Whenever the helicopter personnel were unable to obtain data at the scene, immediately upon arrival at the trauma center they contacted the first responder who had assessed the initial vital signs. In addition they verified the reason for the helicopter request, which was frequently impractical to do at the scene. In some cases the vital signs recorded did not represent simultaneous assessments but did represent the first available signs in this prehospital system.

After the patient's arrival at the trauma center the trauma score was recorded and, subsequently, the ISS and the TRISS probability of survival were calculated. Entrapment and associated fatalities in motor vehicular accidents were noted, and logistic data on each flight were tabulated.

Evaluation of Triage. The correctness of each triage decision was evaluated by the following criteria: patients with TRISS probability of survival less than or equal to 0.90 should have gone to the trauma center, and all others should have been taken to the nearest hospital. The parameters of sensitiv-

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Presented at the Forty-fifth Annual Session of the American Association for the Surgery of Trauma, 12–14 September 1985, Boston.

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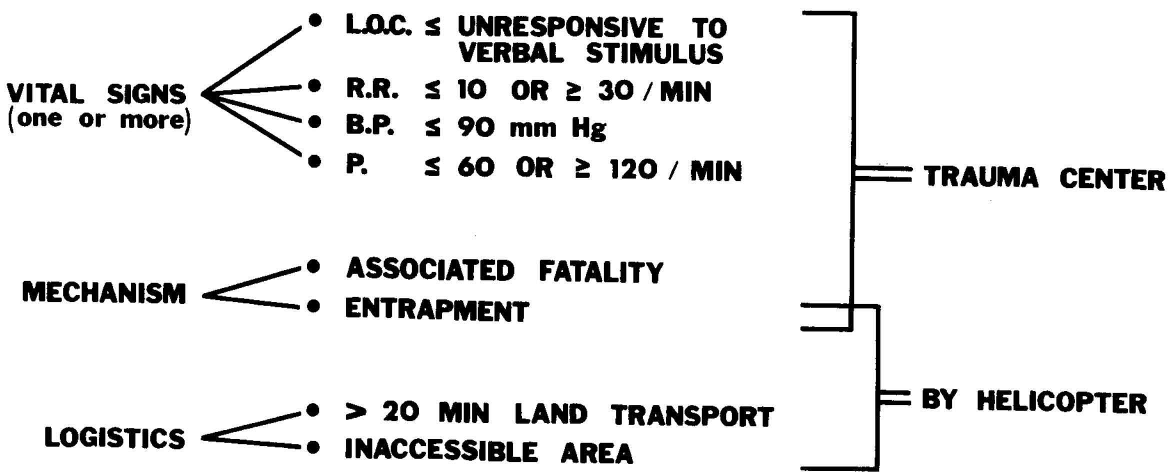

FIG. 1. Field triage criteria for trauma center and helicopter transport.

ity, specificity, and incidence of serious trauma were calculated according to the equations in Table I. Although all patients in this study were in fact transported to the trauma center, field triage performance was analyzed according to the above parameters in order to determine how various criteria would have triaged patients in the study.

RESULTS

A demographic profile of the studied population and mode of injury data are contained in Table II. Figure 2 shows the injury severity distribution. The mean flight distance, mean time at scene, mean length of entrapment, and mean total mission times are shown in Table III. Three patients were retrieved from inaccessible areas

TABLE I
Definitions of indices

$$\text{Sensitivity} = \frac{\text{Number sent who should have been sent}}{\text{Number who should have been sent}}$$

$$\text{Specificity} = \frac{\text{Number not sent who should not have been sent}}{\text{Number who should not have been sent}}$$

$$\text{Incidence of serious trauma} = \frac{\text{Number who should have been sent}}{\text{Total traumas}}$$

TABLE II
Patient demography

Age (yrs): mean = 28.1; range (3 to 81)
M/F = 1.5/1
Mode of injury (%)
- MVA (71)
- Motorcycle (8)
- Pedestrian (3)
- Fall (4)
- Industrial (3)
- GSW (5)
- Stab (1)
- Other (5)

and, in the remaining group, all but five had estimat ground transport time of greater than 20 minutes.

Table IV shows the effectiveness of one or more ba vital signs in identifying the at-risk patient. One hundr seventeen (90%) of the 130 patients had at least one the triage criteria for the trauma center outlined Figure 1; 91 patients (70%) had one or more abnorm vital signs. The 39 patients with normal vital signs h a mean ISS of 14.4 with a TRISS probability of surviv of 0.99 and no mortalities. For 24 of these patients t helicopter had been called because of entrapment.

Table V contrasts the mean TRISS for the group patients who had a given vital sign normal with the me TRISS for those who had that sign abnormal. The larg difference between groups was found in level of co sciousness (LOC). The incidence of serious trauma w 32% for the entire group.

Each one of the four vital signs and entrapment we evaluated individually for sensitivity and specificit Then various combinations were tested for their succe as triage guidelines. Figure 3 and Table VI show th relationship between sensitivity and specificity for se lected triage guidelines studied. In our study populatio one or more abnormal basic vital signs would have triag with a sensitivity of 98% and a specificity of 43%. A more abnormal vital signs were required for triage, th specificity rose to 100%, but the sensitivity fell to 17% Although adding patient entrapment yielded a sensitivit of 100%, this was only a slight increase over the basi guideline's sensitivity of 98%. Furthermore, adding en trapment yielded a specificity of 17%, which was muc lower than the basic guideline's 43%. The best singl vital sign was LOC, which performed with a sensitivity of 93% and a specificity of 85%.

Table VII demonstrates that within the group of 91 motor vehicle accident victims there were no significan differences in severity of injury or outcome between th entrapped and nonentrapped patients. The presence of an associated fatality suggested more serious injury, but

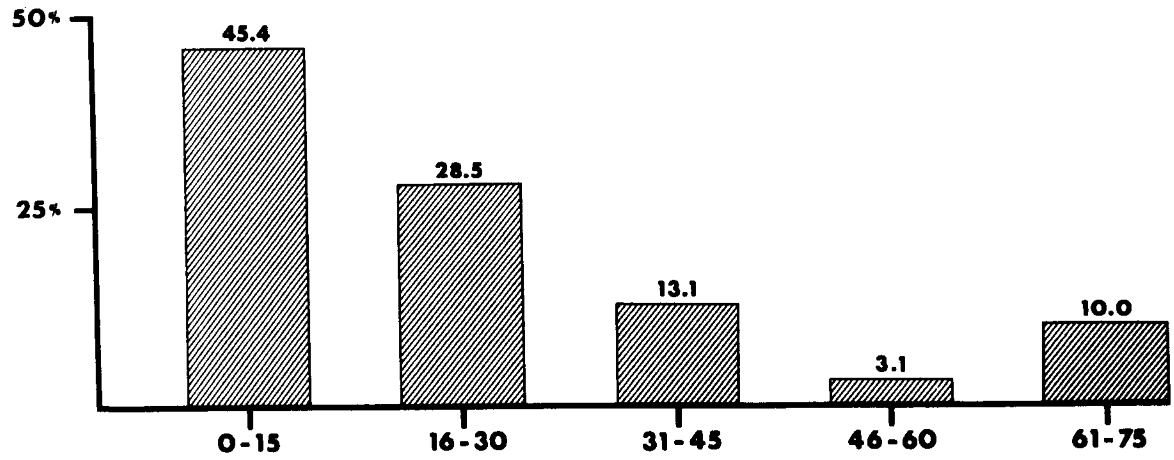

FIG. 2. Injury Severity Score distribution.

TABLE III
Flight data

	Mean	Range
Distance (one way)	17.4 n.m.	3–42 n.m.
Time at scene	18.4 min.	4–85 min.
Length of entrapment	43.2 min.	10–300 min.
Total mission time	44.3 min.	11–122 min.

there were only nine patients in this group. The automobile accident victims had significantly less severe injury than patients injured by other mechanisms including motorcycle, fall, and penetrating trauma.

DISCUSSION

A variety of field triage scoring systems have been reported including the Trauma Score (5), the CRAMS score (9, 13), and the Trauma Index (18). Both physiologic and anatomic criteria have beeen evaluated. Recently, Kane et al. used multivariate analysis to design a field triage instrument which included physiologic, anatomic, and mechanism of injury criteria (15). They concluded that simple checklists performed approximately as well as weighted scales and that no instrument was found to be high in both sensitivity and positive accuracy.

At the time of this study, none of the field triage tools had been tested in an on-scene helicopter transport system, and most authors reporting on helicopter transport programs failed to make clear how the decision to use the helicopter had been made. Cowley et al. (1973) reported on 451 on-scene trauma transports (10). They suggested that a triage tool be based on anatomic and/or system dysfunction. In 1979, Mackenzie et al. reported on 760 on-scene trauma patients transported by helicopter to a trauma center (17). They found that the major cause of death was head injury and that level of consciousness was the most sensitive indicator of a fatal prognosis. Duke et al. reported on 490 on-scene helicopter transports, one fourth of which were requested by personnel with less than EMT training (11).

Law et al. limited their study to 198 trauma patients transported by helicopter who were brought directly to the trauma operating room. They found decreased mentation or coma on admission to predict a poor outcome (16). Baxt compared helicopter and land transport of trauma patients from the scene, suggesting that the decreased mortality rate with helicopter transport was due to the expertise of the helicopter crew (3). Reporting on 100 on-scene trauma transports in a rural area, Urdaneta et al. suggested that it was not possible, using currently available techniques, to prospectively differentiate between patients who will or will not benefit from helicopter transport (20). Fischer et al. (12) reported on 577 on-scene transports in an urban area for which no

TABLE IV
The effectiveness of one or more basic vital signs in identifying the at-risk patient

	n	TS	ISS	TRISS	Mortality	Entrapped	Associated Fatality	Predicted Mortality	Observed Mortality
Total *n*	130	13.1	24.7	0.76	22	66	9	22%	17%, $p < 0.023$
Normal V.S.	39	15.7	14.4	0.99	0	24	4	0%	0%
One or more Abnormal V.S.	91	11.9	29.1	0.66	22	42	5	32%	24%, $p < 0.023$

TABLE V
Comparison of mean TRISS probability of survival for normal and abnormal vital signs

	LOC	RR	P	BP
Mean TRISS for normal V.S.	0.98	0.85	0.82	0.80
Mean TRISS for abnormal V.S.	0.44	0.56	0.63	0.65

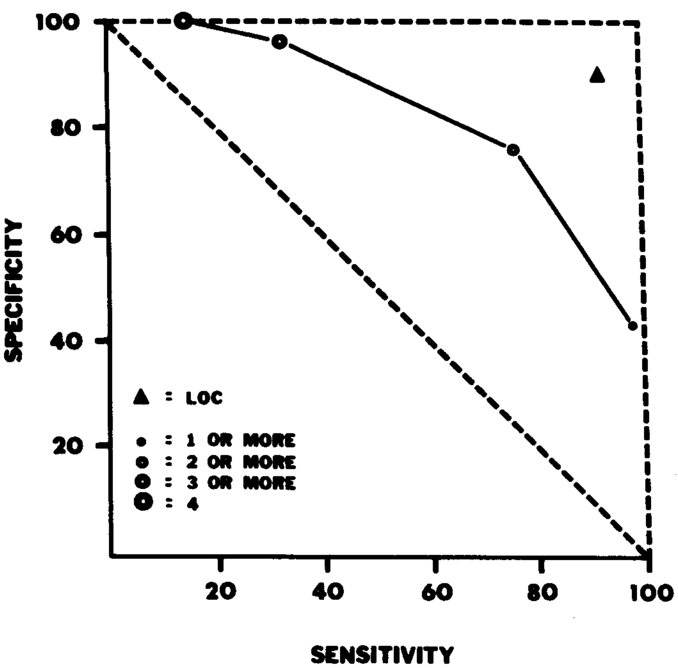

FIG. 3. Sensitivity and specificity of abnormal vital signs triage guidelines.

prehospital screening was done. They suggested that air transport was most appropriate for rural areas and they observed that one third of the patients transported arrived with a Trauma Score of 16 and probably did not need transport. Schwab et al. reported on 52 on-scene helicopter trauma transports with relatively high Injury Severity Scores, seeming to indicate appropriate tri (19).

Studying the effect of on-scene helicopter transpo a multi-institutional study involving 1,273 patients, B et al. reported an actual mortality rate lower that pected (4). However, a relatively low mean ISS sco 21 in this group suggested overtriage in the field. addition, 72% of the patients in this group had a TR probability of survival of 0.9 or greater.

The present study was designed to measure the res of empirically determined triage criteria for an E trauma helicopter system serving a moderately rural a exactly as the system exists. A group consisting of se experienced flight nurses and seven paramedics was structed to record the first available vital signs obtai by the first responder. This sometimes required revi of the tapes from the communication center as well specific call-back to the first responders while they w immediately available. Waiting for trip sheets was acceptable. A retrospective review of over 700 on-sc trauma patients in this program had previously reve that many segments of the standard prehospital f responder data collection system (trip sheets, etc.) w incomplete.

It is recognized by the authors that many intangib such as first responder discretion, may have preselec the population that was studied. However, 90% of patients in this study had at least one of the trau center criteria and 97% had helicopter transport crit as outlined in Figure 1, indicating good compliance w the triage guidelines by prehospital personnel. No ef was made to compare the effect of the helicopter to l transport, and therefore no scientific conclusions can drawn about the advantages of the helicopter. The tistically significant difference between predicted observed mortality rates in this group might suggest t the helicopter or its crew had a positive impact on t patient population, particularly for the more than third who did not receive advanced life support until helicopter crew provided it.

TABLE VI
Performance of selected triage guidelines

		Should			Should Not		Sensitivity	Specificity
		n	Did	Did Not	Did	Did Not		
LOC,BP,RR,P	1 or more	130	41	1	50	38	0.98	0.43
LOC,BP,RR,P	2 or more	129	32	10	21	66	0.76	0.76
LOC,BP,RR,P	3 or more	130	13	29	4	84	0.31	0.95
LOC,BP,RR,P	4 or more	130	7	35	0	88	0.17	1.00
LOC,BP,RR,P,E	1 or more	130	42	0	73	15	1.00	0.17
LOC	1	130	39	3	13	75	0.93	0.85
RR	1	130	22	20	20	68	0.52	0.77
BP	1	129	14	28	20	67	0.33	0.77
P	1	130	18	24	22	66	0.43	0.75
E	1	130	18	24	48	40	0.43	0.45
LOC,BP	1	129	41	1	30	57	0.98	0.66
LOC,RR	1	130	41	1	30	58	0.98	0.66
LOC,P	1	130	42	2	31	57	0.95	0.65

TABLE VII
Differences in severity of injury and mortality by mechanism of injury, entrapment, and associated fatality

	TRISS	ISS	TS	Observed Mortality	*n*
All MVA	0.81	21.2	13.5	9/92 = 0.10	92
All non-MVA	0.64	33.1	12.0	13/38 = 0.34	38
	$p < 0.02$	$p < 0.002$	$p < 0.04$	$p < 0.002$	
		(MVA victims only)			
Entrapped	0.82	20.8	13.8	5/63 = 0.08	63
Not entrapped	0.79	22.1	12.9	4/29 = 0.14	29
	n.s.	n.s.	n.s.	n.s.	
Associated fatality	0.62	32.2	11.9	3/9 = 0.33	9
No associated fatality	0.83	20.0	13.7	6/83 = 0.07	83
	n.s.	$p < 0.05$	n.s.	n.s.	

A mean flight distance of 17.4 nautical miles was consistent with the on-scene helicopter studies already cited, confirming that in most areas including a rural/urban mix, the majority of on-scene flights occur within a 60-mile radius. The mean time at the scene of 18.4 minutes for the helicopter crew indicated good cooperation between the ground and helicopter crews. The mean total mission time of 44.3 minutes was within the 'golden hour,' suggesting that there were few unnecessary delays.

The performance of each triage guideline was judged by using the TRISS probability of survival of 0.90 or less to indicate a valid trauma center candidate. According to this TRISS guideline, the study population had an incidence of serious trauma of 32%, suggesting that two thirds of the patients transported did not need a trauma center. However, if ISS of 16 or greater had been used as the standard, as has been suggested by Kane et al., then 54.6% of the patients were trauma center candidates (15). TRISS was chosen in this study because it has been given more scientific scrutiny (4, 5). Both are normative endpoints and assume that our society can accept that trauma victims who have injuries carrying up to a 10% chance of mortality may be triaged away from a trauma center.

West et al. suggested that using vital signs as the only criteria would lead to neglecting patients who should go to the trauma center (21). We found that using one or more abnormal simple vital signs resulted in a triage guideline with 98% sensitivity and 43% specificity, as judged against TRISS, suggesting overtriage. Using the level of consciousness criterion alone resulted in sensitivity of 93% and specificity of 85%. This triage system would have neglected three patients out of the 42 who needed the trauma center and would have brought in 13 patients not needing the trauma center. Given the realities of the prehospital situation, denying even one or two valid trauma center candidates access to the trauma center could have dire consequences for the credibility of such a highly visible program and may overshadow the concern about transporting patients not in need of the trauma center.

Two thirds of the patients in this study who were involved in motor vehicular accidents were entrapped (mean entrapment time = 43 minutes). Since 24 of the 66 entrapped patients had normal vital signs and ISS scores that did not indicate trauma center need, entrapment by itself as a triage guideline should be reevaluated.

Among the patients who were involved in a motor vehicle accident in which another passenger was killed, higher ISS scores resulted and mortality rate increased. This suggests that the presence of an associated fatality is a valid trauma center triage tool, but the numbers were too small for analysis.

Recently, the American College of Surgeons Committee on Trauma proposed an AVPU system in which unresponsivness to verbal stimulation is a midpoint in a neurologic scale (1). Vocal stimulus is many times the easiest to direct in the field, especially to an inaccessible patient. An excellent measure of the patient's best motor response is an appropriate response to verbal stimulation such as following a command or talking back, even though the response may consist of inappropriate words. This level of responsiveness would suggest that the patient has a Glasgow Coma Scale of 10 or greater.

Statistical evaluations of the basic vital signs and analysis of several mechanisms of injury and time-distance factors as triage guidelines have led to the following conclusions. The presence of one or more abnormal simple vital signs will identify a group of seriously injured trauma patients who may benefit from on-scene helicopter transport to a trauma center. Using this relatively simple nonscoring system of triage, a result yielding high sensitivity is obtained, but moderately low specificity results in overutilization of a trauma center helicopter system. Unresponsiveness to verbal stimulation in the field is the single most predictive triage criterion, yielding the highest sensitivity and specificity. Time-distance factors by which the decision to use the helicopter is made are easily applied and highly compliant criteria for field personnel. Patient entrapment by itself may not be an effective field triage tool for detecting trauma center candidates. Incidence of an associated fatality seems to be a useful trauma center triage tool, but it is relatively uncommon. A scoring system in the field is probably not necessary and may be impractical for most first responders in a rural area served by a helicopter-trauma center EMS system.

Acknowledgment

Preparation of the illustrations by Carol Gagnon is gratefully acknowledged.

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DISCUSSION

DR. C. W. SCHWAB (UMDNJ-Rutgers Medical School, Camden, NJ 08103): I would like to congratulate Doctor Rhodes and his group on a fine paper and one that I think is very timely. Its focus is helicopters, but yet, what it attempts to do is ask the questions: Who is severely injured? Who need Trauma Center?

For this study they defined severe injury in very sim terms: a lowered level of consciousness as manifest by inability to verbally respond, change in respiratory rate, blood pressure, or an elevated pulse rate. In addition, ot modifiers such as entrapment in the vehicle and associ fatality were statistically analyzed to see if they could pre a more severe injury and therefore appropriate use of the ambulance. They arbitrarily used the logistic decision that appropriate helicopter transfer occurred when the time a from the Trauma Center for the 'packaged patient' was minutes or greater. In addition, they called the helico transport appropriate when called to a 'inaccessible area would agree that based on the geography of Eastern Penn vania and Western New Jersey that these are probably app priate logistic decisions.

Retrospectively, then, an analysis of 130 trauma patie who arrived by air was made and using essentially a sin criterion, the TRISS probability of survival, they attempte see if altered verbal response, change in vital signs, etc., w specific, sensitive, and accurate for predicting appropriate of the helicopter evacuation system. Although the sampl somewhat small, 18 patients per month, two obvious poi were made: that lowered level of consciousness, that is inabil to respond to questioning, was the most specific single criter to delineate the question, who is severely injured, and there had an appropriate flight. And second, on the negative s entrapment was not a good predictor for severe injury determinant for aeromedical evacuation.

Possibly not so obvious, but even more important, is t the authors found that an altered level of consciousnes defined by inability to verbally respond combined with abnormality of the vital signs stated was an excellent predic of severe injury, the appropriateness of Trauma Center trans at least, being substantiated by a high TRISS score gre than 0.90.

The simple use of these criteria, if this study holds true larger sampling and when compared to other measures of inj severity, may be a giant step forward. The question rema however, for all of us: Who is severely injured? The questi of what trauma patient needs to be transferred by an ambulance needs to be answered on the basis of not only trau severity, but on logistics! Many scores, indices, and crit have been used to try to answer the question, but I hav point out again that the use of a helicopter is usually one the logistics and skill supplementation unique to the area which the helicopter flies as well as medical need. The logisti criteria must be based on traffic, time of the day, terrain, a a number of other factors. What is 20 minutes in East Pennsylvania for Doctor Rhodes' group and is obviously sound criterion to transport the patient, may in fact have applicability for another region with different geography, pography, and demographics. Each region will have its o unique logistics that need to be analyzed and applied to t reasoning process of when an air ambulance should be used f trauma patient transport.

In addition, the skill level of the first responder at the sce of the accident is of utmost importance in deciding whether medical evacuation is needed. Doctor Rhodes doesn't look this exactly except to say that one third of his patients h only BLS before arrival. Yet in an area where BLS le personnel are the only available responders, criteria to call air ambulance may have to be liberalized in order to suppleme that ground crew. In fact, the aeromedical crew may be t only available prehospital care provider trained in ALS a experienced in massive trauma care for the entire region. A this point, after flight crew arrival, with ground and air forc working together, a second triage could be done to best decide on appropriate mode of transport and level of facility—Trauma Center or local hospital. However, as the authors so tactfully point out, this second triage may in fact have some difficult political scenarios that at present are difficult to reconcile without alienating the well-meaning initial responders.

It was obvious from our experience in Eastern Virginia that on a practical basis integral scoring systems don't seem to work. Over a 2-year period we used ten triage criteria for trauma patients and the use of the air ambulance. These were based on anatomic diagnosis, physiologic derangement, and mechanism of injury. In addition, all our flight crews and ground paramedics were instructed in the use of the Trauma Score (Champion). All run sheets were printed with the Trauma Score with an easy quick reference table for scoring and interpretation. Despite this, the criterion that was used *least* was the Trauma Score and the excuse given was that they did not have enough time to calculate the score. One of several of the other nine criteria were chosen as a 'checklist'; crews found it easier to place the trauma patient in one of the other criteria mentioned. I would agree with the authors and from my own experience then that a checklist is better, more practical, and can be widely applied to all levels of prehospital care providers with little education or risk of subjective error.

I have some questions:

1) How did you arrive at the criteria you used and exclude other criteria? Your criteria may still be too insensitive to pick up additional patients that need the advantage of the Trauma Center. This may in fact explain why your own retrospective application of the TRISS probability of survival showed that only 33% of your patients had TRISS scores 'high enough' for a Trauma Center admission.

2) Was there any reason why you used only TRISS and didn't look at other criteria to define severe injury?

3) Was there a reluctance to use your criteria by rescue workers, ED physicians, or other surgeons at facilities to which you did not fly?

4) Do you have any data on the major injured patients who did not arrive at your center but yet were injured within your region? In particular what criteria were used to triage them away from air ambulance and your Trauma Center?

5) Were there any of your flight crew, either nurses or paramedics, who worked on other ground crews? And related to this, did you notice that there was an increased utilization of your helicopter from the squads or areas in which these people were employed?

I would like to thank the Association on the privilege of discussing this paper and once again thank Doctor Rhodes for what I believe is a major contribution.

DR. MICHAEL RHODES (closing): Thank you, Doctor Schwab, for your comments. We decided to use the TRISS probability of survival as described by Champion and Sacco as a triage endpoint because this methodology has been given some scientific scrutiny. An ISS of 16 or greater as a triage endpoint for trauma center need has not really been studied to my knowledge. In fact, in her early studies, Baker suggested that an ISS of 25 predicted a 10% mortality. Of course, both of these triage endpoints assume that society can accept the fact that patients with injuries predicting up to a 10% mortality may be triaged away from trauma centers.

These field triage criteria were empirically derived but were based on criteria suggested by the American College of Surgeons Committee on Trauma several years ago. The Maryland Institute of Emergency Medical Service Systems in consort with the Maryland State Police MedEvac program has used very similar criteria for many years. They were simple and straightforward and did not require calculation in the field, which is why we adopted them.

We feel that the exceptional compliance with these criteria was a direct result of an extensive educational program in which each ambulance corps spent over 3 hours with our program during orientation sessions. We did this 6 days a week, one or two ambulance corps at a time, over a 3-year period.

We do not know how many patients with serious traumatic injuries within our region went elsewhere. Currently we do not have a method in Pennsylvania for evaluating this. However, with the new legislation in Pennsylvania, we hope to be able to answer these questions in the future.

You asked if we found an increased incidence of flight utilization where members of our flight crew were also members of the ground crew. No, we did not. Although two members of our flight crew do run with paramedic ambulance crews, their squads are primarily local and would probably not need to use the flight program.

Again, thank you very much for the opportunity of the floor. [Applause]