systems injured per patient, mechanism of trauma, ages, and trauma scores.

The time interval from scene of accident to admission to the hospital was similar for both ground and air transport groups, indicating that other factors are important in improved survival for the aeromedical group. Therapeutic interventions including blood transfusions, endotracheal intubation, and the use of Medical Antishock Trousers were significantly more frequent in the air-transported group. Of patients requiring intubation because of significant head and neck or chest trauma, 88% of the intubations were placed under the direction of the flight team prior to arrival at the hospital. Only 47% of the ground ambulance patients requiring intubation had their endotracheal tubes placed prior to arrival at the hospital. Significantly higher percentages of the air-transported group had blood administered prior to arrival at the hospital under the direction of the flight team. In addition, Medical Antishock trousers were more frequently employed in the air-transported group. The aerovacuated patients received a larger electrolyte resuscitation during transport and prior to arriving at the hospital.

The impact of utilization of the Life Flight personnel with critical care training under direct medical supervision had a beneficial effect in that no patients in the air-transported group had deterioration of their vital signs during the transport phase from the referring hospital compared to 43% of the ground group, which did become more hemodynamically unstable. The Life Flight helicopter program carries O− blood on interhospital transports as well as utilizes any blood that is crossmatched at the referring hospital. The flight personnel are skilled in endotracheal intubation as well as other advanced cardiac and trauma life-support techniques. Ventilatory support including the capability of providing PEEP and continuous suction for chest tubes can be provided during air transport. The availability of constant medical supervision via radio and telemetry made other pharmacologic interventions possible during aeromedical transport including treatment of hemorrhagic or cardiogenic shock, dysrhythmias, or increased intracranial pressure from head injuries.

The charges for the helicopter service billed to the patients were similar to ground charges in the area. The establishment of the charges for the helicopter were determined by many internal factors in the medical center. These charges, however, only met 15% of the operational expenses of the helicopter service. The remainder of the operational costs were generated by revenue from inpatient hospital charges and represents an institutional commitment to trauma care. No difference in hospital charges including breakdown by trauma scores could be found between the two groups. These results may be influenced by variables in length of stay, especially in patients with long bone fractures. A larger series of patients may show a favorable financial impact of the helicopter service on patient care.

In summary, analysis of the Duke experience in the helicopter transport of multisystem trauma patients demonstrates that an organized systems approach to trauma care improves survival. In the rural setting, interhospital helicopter transportation provides a lower mortality rate by the prompt extension of Level I trauma center resources and expertise to the primary care hospital rather than by shortened intervals between injury and admission to the trauma center. Aeromedical transportation provided hemodynamic stability and physiologic support in the resuscitation phase of trauma care. Interhospital helicopter transportation was most beneficial to trauma patients with midrange trauma scores between 10 and 5. While charges generated by helicopter transport do not meet operational expenses, these operational deficits were met from hospital patient revenues associated with improved survival.

References

1. Neels S. Army aeromedical evacuation procedures in Vietnam. Implications in rural America. JAMA 1968; 204:309–131.
2. Moylan JA, Pruitt BA Jr. Aeromedical Transportation. JAMA 1973; 224:1271–1273.
3. Thomas F, Clemmer TP, Orme JF. A survey of advanced trauma life support procedures being performed by physicians and nurses on hospital aeromedical evacuation services. Aviat Space Environ Med, December 1985, 1213–1215.
4. Baxt WG, Moody P. The impact of a rotocraft aeromedical emergency care service on trauma mortality. JAMA 1983; 249:3047–3051.
5. Alexander RH, Pons PT, Kriscuer J, Hunt P. The effect of advanced life support and sophisticated hospital systems on motor vehicle mortality. J Trauma 1984; 24:486–490.
6. Boyd D, Mains K, Flashner B. A systems approach to statewide emergency medical care. J Trauma 1973; 13:276–284.
7. Finch HF, Nareff MJ, Watkins PB. Wings for wounded warriors. JAMA 1967; 200:391–398.
8. Champion HR. Reported in National Center for Health Services Research Grant No. HS-02559, 1981.
9. Waller JA. Control of accidents in rural areas. JAMA 1967; 201:176–180.

Discussion

DR. BASIL A. PRUITT, JR. (Fort Sam Houston, Texas): Dr. Moylan, Dr. Georgiade, and their colleagues have demonstrated the importance of stratifying patients by injury severity when assessing outcome, and have presented data indicating that a significantly higher percentage of injured patients with trauma scores between 10 and 5 survived when their interhospital transfer to a Level I trauma center was by helicopter as compared to ground ambulance.

These authors have found that time between the injury and the admission to the trauma center was not influenced by the means of transfer, but that the means of transportation influenced the level of prehospital care applied to the patient. That is, endotracheal intubation, application of MAST trousers, infusion of blood, and the rapid

infusion of intravenous fluids in general could be carried out by flight team personnel prior to and during the aeromedical transfer.

In short, the earlier application of trauma center-directed care appears to be more important than rapidity of patient movement.

The author's experience mirrors that of the U.S. Army Institute of Surgical Research in the aeromedical transfer of literally thousands of burn patients—in which experience we have found that a large percentage of the patients require management of catheter problems, alterations in ventilatory management, or alteration of fluid therapy by the surgeons of our burn teams, either prior to or during flight.

Since speed of transfer doesn't seem to be a significant factor in the outcome of these patients, but prompt institution of trauma center-guided therapy does, do the authors feel that education of and improved communication with their referral sources would improve the level of care given to the ground transport patients?

We insist on physician-to-physician communication before accepting burn patients for transfer, and I wonder whether the authors feel that this could be done in their system of trauma care and whether it would make a difference.

There are several questions the answers to which will assist us in evaluating the authors' conclusions. Since the outcome of a population of trauma patients is strongly influenced by central nervous system injury, it is of concern that a greater percentage of the ground-transported patients, as indicated in both Tables I and II, had CNS involvement, and one wonders what role that played in the observed outcome.

It is puzzling that, with the higher incidence of CNS injury, the ground-transported patients had a higher Glasgow trauma score, and I ask the authors how they might explain that apparent paradox. Since the trauma score may change with time, I also ask the authors whether the postinjury time of trauma score determination was comparable in the two groups of patients.

The authors state that the charges for air medical transfer represented only 15% of costs and that the remaining 85% were subsidized by other inpatient revenues as a most laudable institutional commitment to trauma care. That is, as the authors suggest in their manuscript, a strong argument for improved triage, since 74% of the air-transported patients had trauma scores above 9 or below 4, and outcome in those patients was not influenced by the means of patient transport. Do the authors have a plan to improve triage accuracy within their system?

I compliment the authors on this important study that redirects misplaced emphasis from speed of patient movement by air transport, and demonstrates the advantage of transporting an extension of the emergency center to the injured patient.

As a final question, I ask the authors if they plan to take the next step and include a surgeon in their trauma flight teams?

DR. GEORGE F. SHELDON (Chapel Hill, North Carolina): I enjoyed the paper very much. As we at the University of North Carolina are 8 miles away and back each other up when helicopters develop their inevitable mechanical problems, we see many of the same problems. Dr. Moylan's paper, among other things, proves the value of excellent prehospital control of transport. It documents the value of the skilled flight attendants and nurses that work with Drs. Moylan, Georgiade, and the Duke team.

With only four Level I trauma centers in the state and because most of our hospitals are small and lack the resources to care for the multiply injured patient, the helicopter is needed in North Carolina. Moreover, Susan Baker recently reported that for comparable levels of injury severity score (ISS), mortality rates in rural areas are four times that of patients having the same injury in urban areas.

I would add an interpretation of the data presented by Dr. Moylan. I think the greater time spent in the hospital prior to transport may represent local evaluation and resuscitation time. The problem everyone is addressing is availing the resources of the Level I center to patients within the golden hour.

As someone who is not very enthusiastic about MAST trousers, I would also ask if you have data or strong conviction that MAST trousers have improved outcome. I recognize this is a debatable area.

The last question is philosophical (Slide). Dr. Warren Cole of this Association pointed out a problem that we are going to see more of as we develop sophisticated Level I centers. He pointed out (in 1957) that the mechanisms for obtaining training in trauma are so inadequate that care should be given to development of training programs in the field. We now train 2,750 surgeons a year; 400 remain in general surgery. Level I requirements for directors are that there be general surgeons to direct the trauma teams as Level I leaders. I think one of the exceptions is Dr. Georgiade at Duke, who is a plastic surgeon deeply involved in the trauma transport program.

My last question is, where will we get people to run trauma teams as you have done so well at Duke?

DR. C. WILLIAM SCHWAB (Philadelphia, Pennsylvania): Dr. Haynes and Jones: I rise to compliment the authors on their observations. It is always nice to hear a paper that supports your prejudice. In 1983 we reported a similar study. Unfortunately, we did not have data to look at outcome, but we did notice that helicopters were bringing in sicker people (higher ISS, lower TS) and that these people were surviving. I have several questions for Dr. Moylan.

I take some issue with your methodology and, in particular, your heavy reliance on trauma score as the only barometer of the severity of injury. Why didn't you use the Injury Severity Score and, specifically, why not include a breakdown of the Abbreviated Injury Score (AIS)? Our own observations have been that head injury, in and of itself, is not only the most lethal, but the most costly single injury seen at a trauma center. However, other combinations, particularly head and chest injury, carry a very high mortality and a high cost. It may have been important to see if anatomic injury correlated with cost.

(Slide) As to the economic issues Dr. Moylan introduced, I believe this paper offers too simple a view and, in fact, may be misleading. First of all, this slide shows the data from a 1-year study we performed in southern New Jersey at a state-designated Level I trauma center. It represents an experience with 523 patients (80% blunt MVA's) admitted to a single hospital that receives its entire reimbursement from a state-regulated prospective payment system (DRG). This system is similar to the reimbursement system used for federal medicare. Additionally, during the time that these 523 patients were admitted, prehospital anatomical triage guidelines were practiced by the EMS providers so that true regionalization was taking place. In essence, high severity patients were concentrated in this hospital. As you can see, the average stay was approximately 15 days, the mean ISS was 15.6, and when we compared cost and state reimbursement, we *lost* $3562 on *every* admission. Also note from the slide, as severity of injury increased (higher ISS), so did hospital cost and also the economic loss!

Secondly, if we break out the outliers, as seen in this slide (outliers being defined as those patients that exceeded the normal length of stay for any given DRG), we lost an average of $7200, twice that of all cases. Outliers tend to be the most severely injured patients, and, in our outlier group, 60% had an Injury Severity Score above 16. These patients tend to be those type of patients that helicopters, like those in Chapel Hill or Duke, bring into the medical center. Also notice the increasing loss per case, again correlating with higher ISS or severity of injury.

I realize that New Jersey is probably 5 to 6 years ahead of the United States with regards to its experience with prospective payment, and North Carolina obviously does not have the problem just yet. However, Dr. Moylan, I wonder whether if you were to scrutinize your financial data, would you find among your Medicare/DRG population an experience similar to ours in New Jersey? As prospective payment is adopted by the third party payers to solve the medical inflation problem, and as the elderly population continues to grow, this small hidden problem may come to dominate your fiscal officer's headaches. Our experience with prospective fixed reimbursement has led us to conclude that this is the greatest problem and challenge for future funding of any trauma center, helicopter or not.

Once again, I enjoyed the paper; and I thank the association for the privilege of discussing it.

DR. FRANCIS T. THOMAS (Greenville, North Carolina): Dr. Moylan has presented a very nice study of a patient group with trauma scores between 5 and 10. I think this is one of the first and best communications from a nonurban setting documenting this in a well studied group of patients.

Since Baron Larrey first introduced the ambulance, we have seen a movement towards a rapid transport system for patients, with the helicopter offering our latest option in this area. The "Golden Hour" concept is truly put to the test in a rural environment. The helicopter proliferation, as many of you know, has been exponential. This has resulted in the widespread distribution of hospital helicopters. In many states, the activity has been so intense that it has been referred to as the "helicopter wars."

I think that Dr. Moylan has shown us that there is, indeed, a strong medical rationale for the helicopter, not so much to decrease the time of transport of the patient, but rather to permit the more wide-spread use of field personnel that are highly trained and have the capability of a Level I Trauma Center. This expertise is brought to the patient at the accident site and continued on the way to the hospital.

I have two questions for Dr. Moylan. Joe, what do you feel are the appropriate and optimal distributions for this type of service and for Level I trauma centers? Do we need any more specialization? Does there need to be any redistribution of the type of resources and facilities available in any of them?

Secondly, what can we do to prevent the tragic helicopter crashes that we hear of all too often? Having been through one of these experiences at our hospital, I can tell you that the effect on the entire hospital staff is truly extraordinary.

DR. ARTHUR J. DONOVAN (Los Angeles, California): I had not intended to discuss this paper, but the question of funding for trauma care has been raised, and I rise to comment in that regard.

In Los Angeles, an area of 7 million people, a trauma system was established, with Level I trauma centers appropriately spaced. Within the last 2 years, six private hospitals have withdrawn from the system because of inadequate funding for patients without any or with inadequate payment capability. This has put an enormous strain on the remaining hospitals. Neither the state, the County, nor the Federal Government has been willing to address the issue of funding for the care of the trauma patient. This issue needs to be addressed.

DR. JOSEPH A. MOYLAN (Closing discussion): I appreciate all the discussants and their contributions to what we think is an important issue.

Dr. Donovan, we agree with you that funding is a major problem. The majority of our patients, as you observed, were motor vehicular trauma. In our state there is some mandatory collision insurance that covers some of these hospital charges.

Dr. Thomas, distribution of trauma centers is a sociopolitical problem that is very difficult to deal with. I am not sure I have an answer that I can present in the brief time we have here today.

Dr. Schwab, because we are focusing on the physiologic phase of their care during the first few hours, we chose to use the trauma score, although we do have the ISS and the AIS on all our patients. ISS and AIS are retrospective, based on anatomic injuries and are probably more important for comparing long-term hospitalization and finances. In distinction to New Jersey and the data that you reported, the inpatient revenues that covered our helicopter operation came from the trauma unit itself.

We experienced a budgetary surplus last year in our trauma unit, since most of our patients are not penetrating trauma and do have third party coverage.

Dr. Sheldon, we appreciate the comments you made about MAST trousers. We are also concerned about their hemodynamic value. I think that in many instances, the MAST trousers are used to stabilize long bone fractures. I am not sure what their hemodynamic value is.

In terms of time in the emergency room, we felt that in our series most doctors call us earlier for the helicopter, rather than later when they are transporting them by ground.

How trauma surgeons are going to be trained in the future will be determined by the committment made by general surgical training programs, and we all have to address that issue.

Dr. Pruitt, we do have a medical control officer who accepts every flight as does the Army Burn Center in San Antonio. We do find, however, that there is a gap between what you direct the referring doctor to carry out before you transport and what he actually does.

Again, the difference in the number of head injuries and the Glasgow is an important point, as you have observed. There were a few more head injuries in the ground group. However, they were less severe, as reflected by the higher Glasgow score.

We are not going to send a trauma surgeon on our flights. Basically, the interventions we have found important included intubation, the use of blood, and the placement of chest tubes. Our personnel are skilled in those things, and we do not feel we have the resources to expend a surgeon to do that.