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Original Research

Helicopter Transportation of Brazilian Trauma Patients: A Comparison of Times to Care

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A B S T R A C T

Objective: The purpose of this study was to analyze helicopter emergency medical service (HEMS) transport with secondary land ambulance transfer, comparing landings performed inside and outside the hospital complex to the emergency department.
Methods: This was a cross-sectional observational study of HEMS transports of trauma patients between 2016 and 2018 in southern Brazil. Patients were attended by the HEMS team at the trauma site or stabilized in hospitals nearby and subsequently referred to trauma centers. In this region, no trauma centers have their own helipads so helicopters land in remote areas close to the hospital, which may be inside or outside the hospital complex. Both landings require ground emergency medical service transport, with off-site landings necessitating ground emergency medical service transport via public access roads to reach the hospital. Data were analyzed using descriptive statistics, and on-site and off-site transport times were compared using a *t*-test for independent samples.
Results: Of 176 transports, 28.5% resulted in on-site landings, whereas 71.5% occurred off-site. The ground transport time when the landing zone was off-site was 5 minutes longer than on-site ($P < .001$).
Conclusion: Off-site landings result in longer transports to the emergency room. The construction of helipads in trauma centers can reduce transport time, in addition to reducing the costs and sequelae of trauma.

Each year about 5.8 million people are fatal victims of trauma worldwide, which represents 10% of the global mortality burden.[1] In Brazil, trauma is the third leading cause of death, disproportionately affecting a younger population under 40 years of age.[2] In addition, traumatic injuries are responsible for causing most cases of permanent disability, resulting in high economic and social costs.[1]

The time to definitive treatment is an essential component in the care of traumatic injuries.[3] The "golden hour" is a term well-known in the trauma literature that describes the first 60 minutes after an injury during which stabilization and resuscitation are crucial to positive patient outcome.[4] This concept has become the cornerstone upon which many emergency medical services (EMS) systems base their trauma responses. Although controversy remains on the significance of the golden hour, there is evidence to suggest that delays in certain prehospital time intervals may negatively impact mortality in the undifferentiated trauma patient, specifically transport time, which is the time from leaving the scene to arrival to the hospital.[5,6]

The Serviço de Atendimento Móvel de Urgência (SAMU), or Mobile Emergency Attendance Service, is the national Brazilian EMS system.[2] SAMU is a prehospital care service accessed through a national toll-free telephone number (192). Emergency calls are screened and triaged by a regulating physician who performs objective data collection, determines the level of response (basic or advanced), and dispatches the appropriate unit(s).

Emergency care units are geographically distributed in a strategic arrangement in order to optimize the response time between calls from the population and transportation to and from reference

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hospital services. The priority is to provide assistance to the victim in the shortest possible time. These service units are organized into basic life support (Unidade de Suporte Básico), which is composed of an emergency vehicle driver and a nurse technician, and advanced life support (Unidade de Suporte Avançado), consisting of an emergency vehicle driver or helicopter pilot, a nurse, and a physician.

Helicopter emergency medical services (HEMS) are present in many systems worldwide. In Brazil, HEMS are present in all states and provide medical assistance specifically to trauma victims and patients with acute coronary syndrome and stroke. The majority of HEMS services in Brazil are integrated into the SAMU service.

The HEMS services of SAMU Regional Norte Novo provide coverage for 131 municipalities in the midwest, northwest, and north regions in the state of Paraná. Together with 4 other bases, they configure the HEMS network in the state. These bases are located in the most populous cities and have notably higher call volumes (Fig. 1). A coverage area within a radius of 45 minutes of flight from the base is the operational area, equating to 135 km, with an average helicopter speed of approximately 180 km/h (Fig. 1, red circle).[7] However, the distance traveled and time may not always be consistent given varying weather conditions.

When transported by helicopter, the preferred landing site is at the trauma center's landing zone. However, when a trauma center does not have a landing zone, the landing is performed at a location close to the hospital called a remote landing zone. In these situations, a ground ambulance team must transport the patient from the helicopter to the emergency department (ED) located at the trauma center.[8,9] None of the trauma centers in the state of Paraná, including the coverage area for HEMS of SAMU Regional Norte Novo, have their own landing zones. There are also no designated ambulances for these transports; thus, an advanced life support ambulance must be taken out of service in order to complete the final stage of these patient transports.

Delays in prehospital transport times can significantly impact mortality, and HEMS prehospital times have already been demonstrated to be significantly longer than ground ambulance transportation.[10] Therefore, improving HEMS transport time has the potential to impact mortality. To our knowledge, no previous studies in Brazil have used geospatial analysis to compare transport times from the location of the HEMS landing zone to the trauma center ED. This study aimed to evaluate the transport times for remote landings performed inside and outside the hospital complex.

Materials and Methods

This is a cross-sectional, observational study using data collected from medical records of trauma victims transported by HEMS in a metropolitan region in the state of Paraná, Brazil, from January 1, 2016, to December 31, 2018.

Prehospital time is traditionally separated into 4 discrete intervals: the time from call receipt to dispatch (T1, activation); the time from dispatch to arrival on scene (T2, response); the time from arrival to the scene to departure from the scene (T3, on scene); and the time from helicopter takeoff to the landing site near the hospital (T4, air transport time). Because of the necessity of a secondary ground ambulance to transport the patient from the landing site to the ED, the HEMS service of SAMU Norte Novo includes an extra step (T5, ground transport time), as depicted in Figure 2.

Helicopters landed in remote areas close to the hospital, either inside (on-site) or outside (off-site) the hospital complex (Fig. 3). On-site landings were performed in parking lots on the hospital complex, and off-site landings were either in parking lots or soccer fields close to the trauma center, requiring transportation on public roads to reach the ED.

The locations (geographic coordinates) of the helicopter bases were georeferenced and inserted into a cartographic base of the Paraná state, which was available for free on the Internet at https://mapas.ibge.gov.br/bases-and-referentials/cartographicbases/digital meshes[11] and was downloaded in the shapefile format in order to be worked into the QGIS2.16 software (QGIS Development Team).

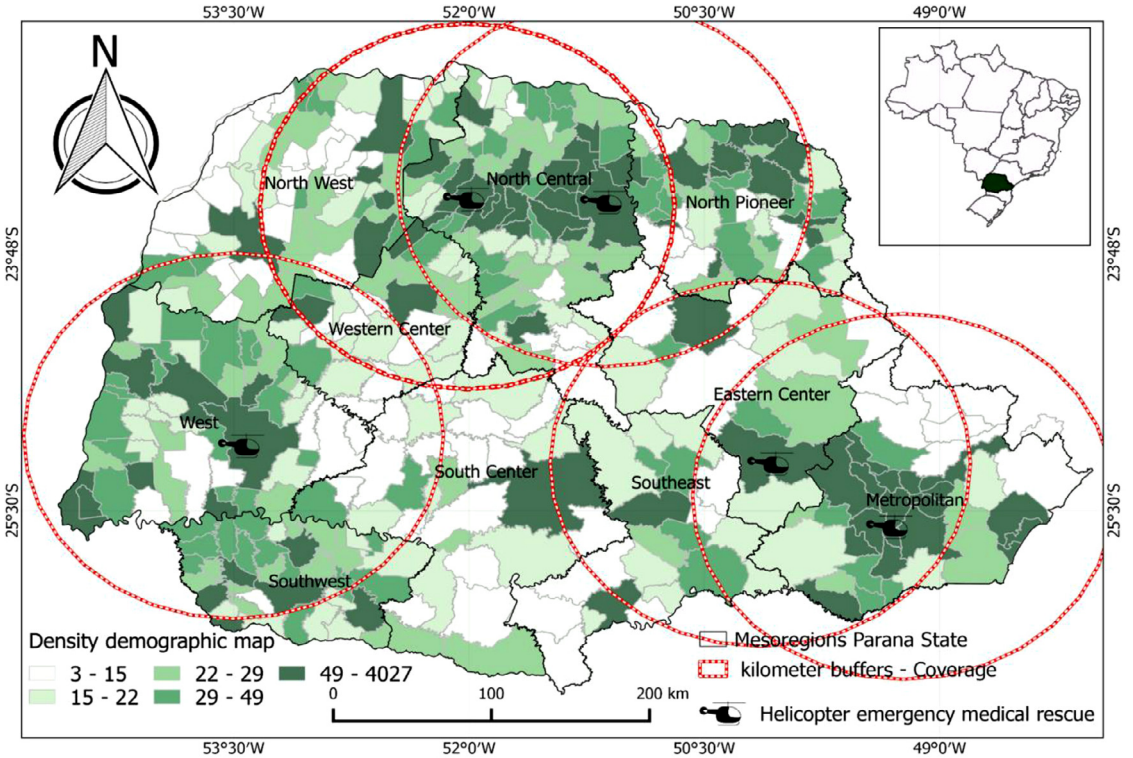

Figure 1. HEMS coverage in the state of Paraná.

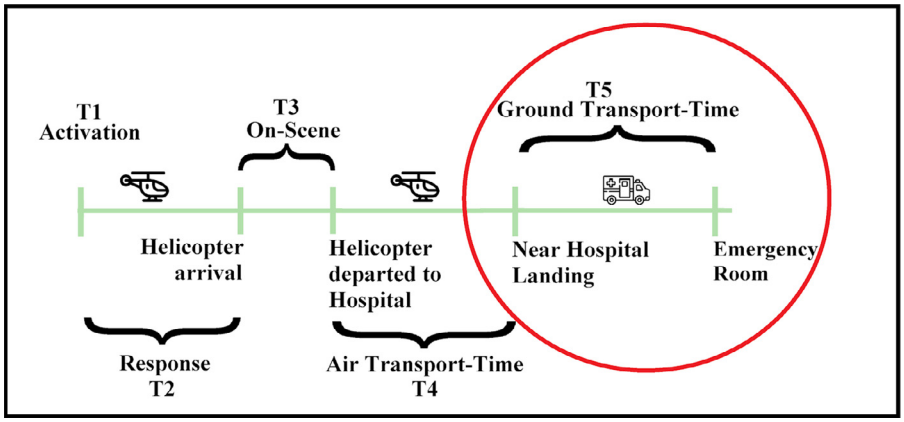

Figure 2. HEMS response time intervals.

The *t*-test for independent samples was used to compare the transport time (T5) between the landings that occurred inside and outside the hospital complex; the level of significance was established at 5%. RStudio (RStudio Team, Boston, MA) was used for inferential analysis.

This study was approved by the Research Ethics Committee of the State University of Maringá (COPEP/UEM), Maringá, Paraná, Brazil, under registration number 2.609.573.

Results

During the study period, 176 trauma victims were transported to trauma centers via HEMS. Of the transports, 101 (57.3%) were primary scene transports, and 75 (42.7%) were interfacility transports. Fifty (28.4%) landings occurred on-site, and 126 (71.6%) occurred off-site (Table 1).

All victims were referred to 1 of 9 trauma centers, 2 of which used on-site landing zones inside the hospital complex and 7 used off-site landing zones. None of the trauma centers had their own individual landing zone (ie, only an unstructured helicopter landing area). A ground ambulance was used for all transports.

The overall transport time was longer when the landing zone was off-site than on-site (100.8 × 113.6 minutes) with statistical significance ($P = .001$), although there were other variables not investigated that could have affected T2, T3, or T4 (Table 1).

The ground transport time (T5) when the landing zone was off-site was 5 minutes longer than when it was on-site (Fig. 4). A Welch *t*-test for unpaired samples revealed a significant difference in the averages ($P < .001$). Off-site landing zones are out of the hospital complex, so the ambulances take longer to access the ED due to greater distances, traffic conditions, and traffic lights compared with on-site landing zones.

Discussion

HEMS is a rarely explored subject in Brazil. This is the first article evaluating the differences in transport time between landings inside and outside the hospital complex. In this region, all HEMS patient transports to trauma centers occur at remote landing zones due to the lack of dedicated trauma center helipads. Off-site remote landing zones resulted in an average delay of 5 minutes compared with on-site landing zones.

In order to transport patients from the landing zone to the ED located at a trauma center, a ground ambulance was used in all cases. In the current study, this contributed to the additional delays in transport.

A recent study conducted in Buenos Aires found the helicopter as a means of reducing transport time, mainly because of the ability to bypass traffic, which is a common cause of transport delays in trauma patients for ground EMS.[12] Even shorter intermediary ground transports can cause significant delays in prehospital time and increase the risk of complications during patient transfer. A study conducted in the United States found that ground transport from a remote landing zone to a trauma center added an average of 5 minutes to the prehospital time.[8] Transport time to definitive care is 1 of the most important metrics in prehospital care.[13] Advanced prehospital care and rapid transportation to specialized health services are essential for the treatment of the trauma patient.[14] The reduction of transport time in trauma is relevant for improving outcomes.

Considering that the operational cost of a helicopter can be up to 15 times higher than a ground ambulance, the need for adequate infrastructure in hospitals is paramount.[15] Both on-site and off-site remote landings in this study required the additional use of a secondary ground ambulance with advanced life support capabilities. As in many parts of the world, EMS is a valuable and limited resource, and removing a ground unit from service comes with a considerable operational cost to the system, resulting in potential gaps in the coverage area.

The additional time spent in executing the ground transport also incurs some risk of delaying the HEMS response time for a new request. Because of the logistics involved in secondary movement of patients, especially with high-level interventions such as the use of ventilators and chest tubes, significant additional time is incurred in secondary transport regardless of the distance involved.

Limitations and Future Research

This study evaluates trauma transports from only 1 base in the Brazilian state of Paraná, thus limiting the generalizability of our results. Additionally, factors such as weather, traffic related to ground transportation, and distance from the landing zone to the trauma center were not evaluated. We were also unable to correlate outcome data, such as mortality, with delays in transport. Future research should focus on outcome data to determine if there is any negative impact from patient complications due to delays in care related to additional transport time. Additional research on the operational costs of using ground ambulances to transport these patients could potentially justify infrastructure changes necessary to place landing zones at trauma centers.

Conclusions

Trauma centers in the SAMU Norte Novo region of Brazil lack dedicated landing zones, necessitating the use of remote landing zones and ground advanced life support ambulances for the final leg of patient transportation to the ED. Off-site remote landing zones resulted in a further delay of ground transportation (T5) of 5 minutes compared with on-site remote landing zones. Landing within the

Figure 3. (A) On-site landing (70 m). (B) Off-site landing (2 km).

hospital complex reduces the overall transport time. Considering that time is a predictive factor, the efficiency of the air medical transport of trauma patients is influenced by the presence of a landing zone in the trauma center. The construction of designated landing zones within trauma center complexes has the potential to reduce transport times. Additional research is needed to determine if these interventions would minimize transport complications and reduce operational costs.

Table 1
Transport Time Intervals for On-site and Off-site Landings

	On-site Landings 50 (28.4%)	Off-site Landings126 (71.6%)	*P* Value
T1	Not recorded	Not recorded	—
T2, min (SD)	20.4 (± 9.55)	24.10 (± 12.66)	.020[a]
T3, min (SD)	38.5 (± 29.77)	37.88 (± 22.30)	.890
T4, min (SD)	16.2 (± 6.96)	18.20 (± 9.09)	.110
T5, min (SD)	**10.0** (± 3.45)	**15.22** (± 4.44)	**.001**[a]
Overall transport time, min (SD)	100.8 (± 45.09)	113.61 (± 36.55)	.001[a]

The ground transport time (T5) when the landing zone was off-site was 5 minutes longer than when it was on-site.
[a] *t*-test significance.

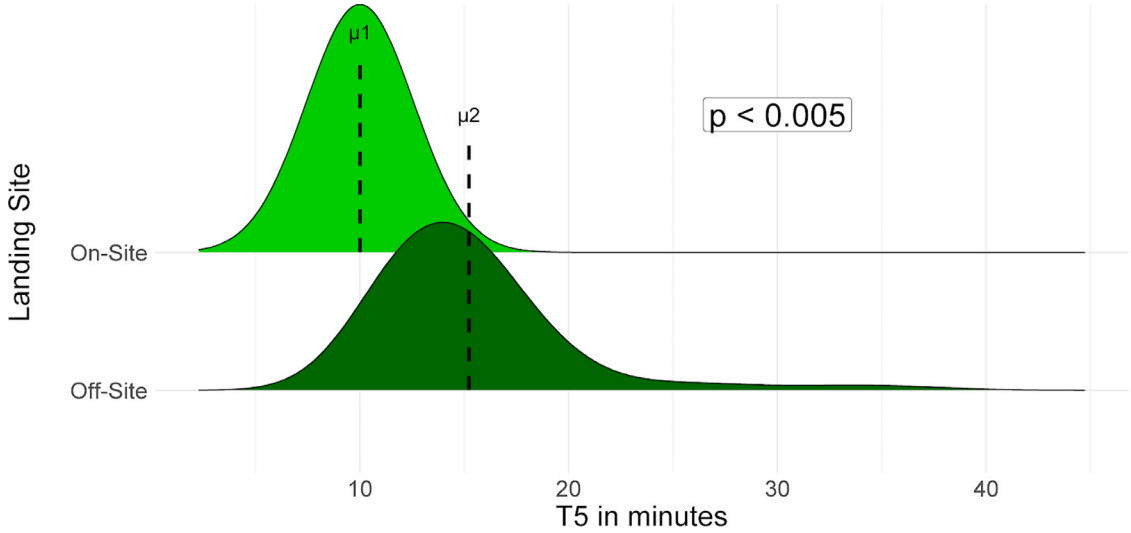

Figure 4. The average transport times for on-site and off-site landings.

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