Causes of delay during interfacility transports of injured patients transported by air ambulance

Brodie Nolan, Barbara Haas, Homer Tien, Refik Saskin & Avery Nathens

To cite this article: Brodie Nolan, Barbara Haas, Homer Tien, Refik Saskin & Avery Nathens (2019): Causes of delay during interfacility transports of injured patients transported by air ambulance, Prehospital Emergency Care, DOI: 10.1080/10903127.2019.1683662

To link to this article: https://doi.org/10.1080/10903127.2019.1683662

Accepted author version posted online: 22 Oct 2019.
Short Title: Delays during interfacility transport

Causes of delay during interfacility transports of injured patients transported by air ambulance

Brodie Nolan, MD MSc¹, Barbara Haas, MD PhD², Homer Tien, MD MSc³, Refik Saskin, MSc⁴, Avery Nathens MD MPH PhD²

¹St. Michael’s Hospital, Department of Medicine, University of Toronto; Ornge
²Sunnybrook Health Sciences Centre, Department of Surgery, University of Toronto
³Sunnybrook Health Sciences Center, Department of Surgery, University of Toronto; Ornge
⁴Institute for Clinical Evaluative Sciences, Toronto

Corresponding author: Brodie Nolan, 30 Bond Street, Toronto ON M5B 1W8. Tel: (416) 864-5095 Fax: (416) 864-5341. Email: brodie.nolan@mail.utoronto.ca

ABSTRACT

Background:

Many severely injured patients are initially brought to a non-trauma centers for initial assessment and stabilization. Air ambulance services are commonly used to expedite interfacility transport of injured patients to trauma centers. Little is known of the types of delays experienced during interfacility transports. The purpose of this study was to identify specific causes of modifiable delays and estimate the attributable time associated with each of these delays.

Methods:

This was a retrospective cohort study of injured patients undergoing interfacility transfer to a trauma center who were transported by a provincial air ambulance service between January 1, 2014 and December 31, 2016. Electronic patient care records were screened and then manually reviewed to identify causes of delay during the interfacility transport process. The attributable time for each of these delays was also estimated.
Results:
There were 932 injured patients emergently transported by air ambulance from a community hospital to a trauma center over the 3-year study period from which 458 unique causes of delay that were identified. The most frequent cause of delays to sending facility were refueling (38%), waiting for land emergency medical services escort (25%) and weather (12%). The most common in-hospital delays included waiting for documentation (32%), delay to intubate (15%), medically unstable patient (13%) and waiting for diagnostic imaging (12%). The most frequent delays to receiving/handover included waiting for land EMS escort (31%), trauma team not assembled (24%) and weather (17%). In-hospital delays with the longest average length of delay included chest tube insertion (53 minutes), intubation (49 minutes) and delays for diagnostic imaging (46 minutes).

Conclusions:
In conclusion, we identified numerous modifiable causes of delay during interfacility transport. Efforts to reduce these delays can be made at both the air ambulance and hospital levels.

Keywords: trauma, air ambulance, interfacility transfer, prehospital care

BACKGROUND
Timely access to definitive care is a critical component of modern trauma systems and has been shown to improve patient outcomes after injury (1-3). Conversely, delays to a trauma center for definitive care and management of severe injuries has been associated with increased morbidity and mortality (6). Due to the vast Canadian geography and relative scarcity of specialized trauma centers, almost 66% of severely injured patients are initially brought to a non-trauma center for initial assessment and
stabilization(4). Many of these patients are later transferred to a trauma center by either air or land transport; the transfer process is referred to as interfacility transfer (5).

Compared to direct transport to a trauma center from the scene of injury, interfacility transfer by definition is associated with delays to definitive care (5). The interfacility transfer process requires the initial health care team to first assess and resuscitate the patient, and then to determine the need to initiate a request to transfer the patient to a trauma center. Once the patient is accepted by the trauma center, an interfacility transport needs to be organized and dispatched. However, there likely are modifiable components to expedite the entire transfer process as the time needed to complete an interfacility transfer can vary significantly (5). Neither the nature of these potentially modifiable delays, nor their specific impact, are well understood.

Interfacility transport refers to the time from dispatch of the transporting medical team to arrival of the patient at the receiving facility (5). Previous work has focused on expediting the initial decision making to transfer the patient to a trauma center (6-8). However, very little work has been done to describe causes of delay in the actual transport process to a trauma center, once an interfacility transfer has been initiated. A detailed analysis of the types and impact of delays during the process of interfacility transport is essential to designing strategies to mitigate these delays. The primary objective of this study was to identify specific causes of modifiable delays and estimate the attributable time associated with each of these delays.

**METHODS**

*Study design*

This was a retrospective cohort study of injured patients undergoing interfacility transfer to a trauma center who were transported by air ambulance. The study objective was to
evaluate the causes, frequency, and duration of delays during interfacility transport.

Ethics approval for this study was obtained from the research ethics board at the University of Toronto.

Setting

The study was conducted in Ontario, Canada. Ontario has 9 adult trauma centers and roughly 150 other acute care hospitals that are non-trauma centers. Fifteen percent of the population on Ontario lives greater than a 60 minutes from a trauma center and fewer than half of all severely injured patients are transported directly from the scene to a trauma center (9). Ornge is the sole provider of air medical transport and critical care transport (land and air) for interfacility transfers in the province. Ornge operates the largest air ambulance fleet in Canada. The service has nine bases that operate rotor or fixed-wing aircraft with a fleet of twelve Leonardo AW-139 helicopters and eight Pilatus Next Generation PC-12 airplanes (Figure 1). Eight helicopters and four airplanes are operational on any given day. Resources are assigned based on closest base with the fastest resource that has the appropriate level of care required. Typically rotor-wing resources transport patients over distances less than 240km and fixed-wing resources are preferred to transport patients greater than 240km. Aircraft are staffed by advanced care and critical care paramedics who are trained in a number of advanced procedures including intubation and airway management, needle thoracostomy, cricothyrotomy and are trained to transfuse blood products, operate ventilators and use infusion pumps. A transport medicine physician provides online medical oversight.

Data sources

Data were derived from a database of electronic patient care records (ePCR) at Ornge which includes all patients transported by Ornge paramedics. The ePCR includes
data pertaining to patient demographics, reason for transfer, vital signs, medications given and interventions performed. Paramedics also complete a narrative text of the transport and could assign standardized delay codes to the call, which are selected by a drop down menu in the charting software. In addition, there are various times associated with each transfer that were entered by paramedics and collected in the ePCR (Figure 2). These include the time of dispatch, the time the crew leaves their base, the time they arrive at sending facility landing site, the times they arrive and depart from patient bedside, the time they depart from sending facility landing site, the time they arrive at the receiving trauma center landing site and the time they handover to the trauma team.

**Study population**

All emergent interfacility transfers for injured patients transported to a trauma center by either fixed or rotor-wing resources between January 1, 2014 and December 31, 2016 were included. Patients with a primary medical reason for transfer, those who were transported to a non-trauma center or were transported by a land ambulance were excluded from the study.

**Identification and classification of delays**

The primary objective of this study was to identify the frequency and causes of delays during interfacility transport. In addition, the total attributable time for each delay was evaluated.

Using the times captured in ePCR, three time intervals were created for each patient transport. These times included: i) the time-to-sending interval, which was measured from the time of dispatch to arrival to patient bedside (excluding flight time); ii) the in-hospital time interval, defined by the time from paramedic arrival to patient bedside to departure with patient; and iii) the time-to-receiving/handover interval, which was
measured from the time of departure with patient to handover to the trauma team (excluding flight time) (Figure 2). Due to interest in the modifiable aspect of interfacility transport, the flight times for both the time-to-sending and time-to-receiving/handover intervals were not included in the calculation of these time intervals.

Given the large number of records and the need for manual review of the ePCR, a screening process was used to identify patients that were likely to have experienced a delay during their interfacility transport. The screening process involved using three approaches. First, charts were identified for review if there was a standardized delay code entered by paramedics. These delay codes are pre-determined and can be added by paramedics to the patient care record at any point if they deem appropriate. Second, the free-text narrative field of each patient record was searched for the terms “delay” “prolong” “wait” or “duty out”, including common misspellings of these words. Any patient record containing these terms was then flagged for review. Lastly, all patient records that had transport times exclusive of flight times above the 75th percentile for overall time to complete interfacility transfer, time-to-sending-hospital, in-hospital or time-to-receiving/handover (excluding flight times) were also manually reviewed.

Any patient identified through any one of these screening methods had their entire Ornge electronic patient care record manually reviewed to search for causes of the delay. In the case that a patient was positively screened but no reason for delay was identified, no delay reason was recorded for that patient. Likewise, if a patient had a delay code entered by the paramedics but there was nothing to substantiate the reason for delay, no delay reason was recorded. A delay was defined as anything the paramedics identified in their charting that hindered or postponed transport. Identified causes of delay were then coded and categorized into time-to-sending, in-hospital and time-to-receiving/handover
delays. The frequency of each type of delay was recorded. A 10% random sample of patient records that were not identified through our search strategy were also manually reviewed to validate these screening methods and to inform if these search parameters should be extended. The screening approached did not identify any additional incidents or causes of delay identified in the sample.

**Attributable delay and length of delay analysis**

Having categorized causes of delay, the mean time attributable to each cause of delay was evaluated. Mean times for time-to-sending, in-hospital and time-to-receiving/handover were calculated for each sending facility using records where no delay had been identified. Similarly, times for the interval where a delay was identified were determined. The difference between the two was the “attributable time of delay” for that type of delay (Figure 3). The “total attributable time” was then calculated for each delay type as the product of its duration and its frequency such that it represents the cumulative time (in minutes) that a delay was responsible for. This was done for each sending facility, and then summed across all facilities. Ultimately, the average length of delay was calculated by dividing the total attributable time by the frequency of delay type.

**RESULTS**

There were a total of 15,798 patients emergently transported by air ambulance over the 3-year study period, of which 932 were injured and transported from a community hospital to a trauma center. Rotor-wing resources transported 71% of injured patients. The screening method identified 552 (59%) patients whom required manual review of their electronic patient records and from which 329 (35%) patients were identified as having at least one delay during their transport. There were a total of 458
unique causes of delay that were identified. Of the 329 patients who experienced a delay during interfacility transport, there were 234 (71%) patients with a single delay during their transport, 67 (20%) patients with two delays, 24 (7%) patients with three delays and 2 (1%) each with four and five delays, respectively. Rotor-wing transports accounted for 70% of delays identified.

**Frequency and total attributable time of delays**

The most frequent cause of delays to sending facility were refuelling (38%), waiting for land emergency medical services (EMS) escort (25%) and weather (12%) (Figure 4). The most common in-hospital delays included waiting for documentation (32%), delay to intubate (15%), medically unstable patient (13%) and waiting for diagnostic imaging (DI) (12%). The most frequent delays to receiving/handover included waiting for land EMS escort (31%), trauma team not assembled (24%) and weather (17%).

The delays to sending facility with the highest total attributable time were refuelling (1249 minutes), waiting for land EMS (898 minutes) and weather (478 minutes) (Figure 5). The in-hospital delays with the highest total attributable time included delay to intubate (1226 minutes), delays for DI (911 minutes), delays waiting for documentation (801 minutes) and medically unstable (693 minutes). The delays to receiving/handover with the highest attributable time were trauma team not assembled (153 minutes), waiting for land EMS escort (115 minutes) and weather (113 minutes). We examined the individual cases involved in delays due to the trauma team not being assembled and found that the mean delay is significantly skewed by two patients. These two patients both sustained isolated head injuries and had a 100-minute and 40-minute
delay due to handing over to the neurosurgical team at the receiving trauma center. All other delays waiting for the trauma team to assemble were less than 10 minutes.

**Average length of delay**

Delays to sending facility with the highest average length of delay were dispatch issues (23 minutes), restocking aircraft (21 minutes) and crew change (20 minutes) (Table 1). In-hospital delays with the longest average length of delay included stabilization of patient in operation room (77 minutes), chest tube insertion (53 minutes), multi-casualty incident (50 minutes), delay to intubate (49 minutes) and delays for DI (46 minutes). Delays to receiving/handover with the highest average length of delay were weather (23 minutes), trauma team not assembled (22 minutes) and equipment issues (15 minutes). Removing the two patient outliers mentioned above with prolonged times handing over to the neurosurgical team resulted in the average length of delay of 3 minutes for team not assembled.

**DISCUSSION**

Delays in interfacility transfer are due to failure to immediately recognize the need for transfer, prolonged evaluation or unnecessary interventions, and waiting for transportation.(5,10,11) The failure to immediately recognize the need for transfer is multifactorial. There are some well-known risks for under-recognition of injured patients. These include elderly patients, decreased level of consciousness, presence of intoxication, female sex and falls.(12,13) Another significant cause of delay to interfacility transfer is prolonged evaluation. Patients transferred from non-trauma centres that have surgical specialties available and access to computed tomography (CT) scans have prolonged in-hospital times compared to hospitals lacking these resources.(11) One small study identified modifiable causes of delay to arriving at the
sending facility included refuelling the aircraft, delays related to crew changes and being
cancelled off from transporting a patient and then later called back.(5)

In this study identified multiple modifiable causes of delay during the process of
interfacility transport of injured patients transported by air ambulance. There are three
key findings in this study. First, it is important to assess both the frequency and duration
of delay, as many of our high frequency delays were short in duration. Second, patients
who had invasive procedures (ie. intubation, chest tube insertion) and advanced DI at the
sending facility experienced the longest delays. Third, improving communication
between local EMS and air ambulance can reduce delays incurred by waiting for land
EMS escorts.

Our findings on in-hospital delays highlight the importance of understanding both
the frequency and duration of delays. For example, waiting for documentation was
responsible for 32% of all in-hospital delays but had the lowest impact on length of
delay, with an average delay of 15 minutes. Likewise, both the stabilization of a patient in
the operating room and mass-casualty incidents were some of the least frequent delays
encountered in hospital however had significant impacts on time resulting in,
respectively, an average delay of 77 minutes and 50 minutes. This approach can be useful
to understand where to put efforts into improving the trauma transport system. For
example, efforts to reduce frequent yet smaller delays such as waiting for documentation
could help our overall trauma system efficiency. On the other hand, rare delays such as
mass casualty incidents, while significant on a patient level are a poor focus for systemic
improvements.

Another finding in our study was that invasive procedures done at a non-trauma
center result in some of the longest delays to interfacility transfer. If a patient needed to
be intubated once the flight paramedics arrived (15% of all in-hospital delays), it increased the in-hospital time by 49 minutes. Likewise chest tube insertion resulted in an average delay of 53 minutes. There are many sending facilities in our trauma system that have a low volume of acutely injured patients which is may be a contributing factor to the resultant delay these procedures cause as physicians who are unfamiliar with technique or equipment available in these high-risk situations may be uncomfortable proceeding without the backup of another physician or the flight paramedics. Furthermore, it is possible that patients may continue to deteriorate or previously unidentified injuries are recognized, such as worsening pneumothorax or hemothorax resulting in a delay to initiate these procedures. Another cause related to delays from procedures may be from a lack of familiarity with the physiologic changes and hypobaric environments associated with air transport (14). Sending physicians may be unfamiliar with the need to place chest tubes for smaller pneumothoraces at risk of developing tension over long distances or the challenges associated with intubation in an aircraft, which could result in a delay to initiate these procedures until the paramedic crew arrives. Communication between the sending physician and transport medicine physician could help optimize patients for transport prior to arrival of the transporting paramedics and reduce these in-hospital delays.

Additionally, airway management in injured patients is inherently challenging and may also precipitate a delay for appropriate preparation and execution(14). Another significant cause of in-hospital delay is waiting for DI. Delays due to DI accounted for 12% of all in-hospital delays and resulted in an average delay of 46 minutes. One study found that 60% of all interfacility transfers that have CT scans imaging done at the sending facility have at least one CT scan repeated at the trauma center(15). Efforts to
reduce delays caused by DI may include a discussion between the sending and trauma physicians to clarify the necessity of advanced DI prior to transport.

Our findings expand on the limited understanding of interfacility delays and serves to better characterize modifiable delays at a systemic level. Many sending facilities in our trauma system do not have a helipad on site or require the aircraft to land at a local airport away from the hospital and then have a local land EMS crew pick them up from the airport and bring them to the sending facility. This effort requires coordination from our air ambulance services as well as local EMS systems to ensure an ambulance is available when the aircraft lands. We found there is often a breakdown of this coordination resulting in the flight paramedics waiting an average of 14 minutes for a land EMS escort to arrive. Refuelling is a challenging delay to address. All aircraft are limited to certain weight capabilities, with rotor-wing resources being the most limited. The more fuel they carry the further they can travel but less weight they can take on with regards to equipment, patients and patient escorts such as family members. Efforts are made to keep fuel levels sufficient to transport most patients within the rotor-wing mission profile however sometimes if there are longer distances travelled or recent flight was complete the aircraft needs to be refuelled.

Overall, delays to receiving trauma center and handover were relatively uncommon. All causes of delay to receiving accounted for only 29 of all 458 delays identified the study. As discussed above, like many of our sending facilities, some of our receiving trauma centers do not have a rooftop helipad and require a land EMS escort from the landing site to the trauma bay. Waiting for a land EMS escort was the most common cause of delay to receiving/handover, resulting in 31% of all handover delays and had an average delay of 13 minutes. Once again, improved communication between
air ambulance and land EMS services may improve coordination and lessen the impact of this delay.

It should be noted that almost 30% of patients identified as having a delay during interfacility transport experienced more than one delay. This is significant because having even two or three shorter delays will lead to clinically significant total delay in transfer. For example a patient who three of the most common but shortest delays; such as refuelling, waiting for land EMS escort and delay to receiving documentation would incur around 45 minutes of total delay time during their transport. That may be long enough to cause patient harm due to delay to definitive care at a trauma center.

There are several limitations to this study that warrant discussion. This study relied on delays that were identified by paramedics by either delay codes or written text describing the delay that occurred. As such there are likely cases where a delay did occur but no documentation was done and thus we would not have captured those delays in this study. Additionally, paramedics may have been less likely to report causes of delay that resulted from their actions. It was not feasible to obtain individual medical records from each sending facility to assess the physician or nursing notes to see if they documented any delays incurred on the paramedic side that we did not capture. However, our study does hold face validity with previous work identifying causes of delay to interfacility transfer (5). Another limitation to this study is the potential for measurement error in calculating the attributable delay time and average time per delay. Delay times were estimated using time stamps of a patient transport entered manually by paramedics, something that may be done in real time or retrospectively after the patient is transported. This approach could lead to either an overestimate or underestimate of time of delay, however is unlikely to result in a significant bias in our results.
In conclusion, we identified numerous causes of delay during interfacility transport. Efforts to improve communication between air ambulance service and local land EMS services should be made in an effort to reduce the impact of delays to both sending a receiving hospitals caused by a lack of land EMS escort. Patients requiring intubation or chest tubes experience delays of more then 50 minutes. Ensuring physicians are comfortable with and equipment is readily available for these life saving interventions may help expedite transport. Patients undergoing advanced DI after the decision to transfer had been made should ensure the timing does not affect the patient’s transport and deferral of further DI until arrival at the trauma center should be considered. The data from this study has been shared locally with key stakeholders in both aviation and paramedic practice at Ornge. Outreach with both hospitals and local EMS stakeholders has begun through the use of online videos and in-person communication to flag causes of delay that have been identified. Future research should be directed at strategies to reduce these delays and assess the efficacy of reducing transport times to ensure injured patients arrive to definitive care in a safe and timely manner.

Author Contributions
All authors have contributed to the design, analysis and interpretation of the data. All authors have reviewed and approve of the final submitted version of the manuscript.

Conflict of Interest Statement
There are no conflicts of interest to declare.

Financial Disclosures
Funding for this study was provided by the Canadian Association of Emergency Physicians.
Financial support
Junior investigator grant ($5000 CAD) awarded to Brodie Nolan by the Canadian Association of Emergency Physicians

Conflicts of interest
There are no conflicts of interest to declare

Meetings presented at
None

REFERENCES


Figure 1: Map of Ontario with Ornge bases and assets (rotor and fixed-wing)
Figure 2: Measurement of time intervals and grouping of delays during interfacility transport

Figure 3: Measurement of attributable time of delay
Figure 4: Frequency of identified causes of delay
Figure 5: Pareto charts of total attributable time (in min) and cumulative percent for each cause of delay

Table 1: Mean length of delay in minutes for each identified cause of delay

<table>
<thead>
<tr>
<th>Delay to sending facility</th>
<th>Mean delay in min (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispatch issues</td>
<td>23.5 (42.7)</td>
</tr>
<tr>
<td>Restocking aircraft</td>
<td>21.2 (18.5)</td>
</tr>
<tr>
<td>Crew change</td>
<td>20.6 (19.4)</td>
</tr>
<tr>
<td>Cancelled and called back</td>
<td>16.2 (12.8)</td>
</tr>
<tr>
<td>Weather</td>
<td>15.4 (37.3)</td>
</tr>
<tr>
<td>Mechanical</td>
<td>14.3 (29.1)</td>
</tr>
<tr>
<td>Waiting for land EMS escort</td>
<td>13.6 (23.0)</td>
</tr>
<tr>
<td>Refuel</td>
<td>12.4 (22.8)</td>
</tr>
<tr>
<td>Triage</td>
<td>7.7 (13.7)</td>
</tr>
<tr>
<td>Other</td>
<td>4.8 (13.8)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In-hospital delays</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stabilization in operating room</td>
<td>76.7 (69.6)</td>
</tr>
<tr>
<td>Other</td>
<td>54.0 (55.2)</td>
</tr>
<tr>
<td>Delay for chest tube</td>
<td>53.4 (52.8)</td>
</tr>
<tr>
<td>Multi casualty incident</td>
<td>50.0 (46.7)</td>
</tr>
<tr>
<td>Delay to intubate</td>
<td>49.0 (37.6)</td>
</tr>
<tr>
<td>Delay for diagnostic imaging</td>
<td>45.6 (41.3)</td>
</tr>
<tr>
<td>Equipment issues</td>
<td>43.4 (38.9)</td>
</tr>
<tr>
<td>Reason</td>
<td>Delay (SD)</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Medically unstable</td>
<td>31.5 (36.5)</td>
</tr>
<tr>
<td>Confirming disposition/receiving</td>
<td>28.8 (20.4)</td>
</tr>
<tr>
<td>Delay for cast/splint</td>
<td>23.7 (50.2)</td>
</tr>
<tr>
<td>Waiting for blood products</td>
<td>17.2 (19.9)</td>
</tr>
<tr>
<td>Waiting for documentation</td>
<td>15.1 (29.0)</td>
</tr>
</tbody>
</table>

**Delay to sending facility**

<table>
<thead>
<tr>
<th>Reason</th>
<th>Delay (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather</td>
<td>22.6 (17.3)</td>
</tr>
<tr>
<td>Trauma team not assembled</td>
<td>21.9 (43.3)</td>
</tr>
<tr>
<td>Equipment issues</td>
<td>15.5 (30.7)</td>
</tr>
<tr>
<td>Waiting for land EMS escort</td>
<td>12.8 (13.9)</td>
</tr>
<tr>
<td>Refuel</td>
<td>5.5 (2.1)</td>
</tr>
<tr>
<td>Mechanical</td>
<td>0.5 (0.5)</td>
</tr>
<tr>
<td>Other</td>
<td>0.5 (0.5)</td>
</tr>
</tbody>
</table>

SD = standard deviation