Timeliness in obtaining emergent percutaneous procedures in severely injured patients: How long is too long and should we create quality assurance guidelines?

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Background: Modern trauma care relies heavily on nonoperative, emergent percutaneous procedures, particularly in patients with splenic, pelvic and hepatic injuries. Unfortunately, specific quality measures (e.g., arrival to angiography times) have not been widely discussed. Our objective was to evaluate the time interval from arrival to initiation of emergent percutaneous procedures in severely injured patients.

Methods: All severely injured trauma patients (injury severity score [ISS] > 12) presenting to a level 1 trauma centre (2007–2010) were analyzed with standard statistical methodology.

Results: Among 60 severely injured patients (mean ISS 31, hypotension 18%, mortality 12%), the median time interval to the initiation of an angiographic procedure was 270 minutes. Of the procedures performed, 85% were therapeutic embolizations and 15% were diagnostic procedures. Splenic (median time 243 min, range 32–801 min) and pelvic (median time 278 min, range 153–466 min) embolizations accounted for 43% and 25% of procedures, respectively. The median embolization procedure duration for the spleen was 28 (range 15–153) minutes compared with 59 (range 34–171) minutes for the pelvis. Nearly 22% of patients required both an emergent percutaneous and subsequent operative procedure. Percutaneous therapy typically preceded open operative explorations.

Conclusion: The time interval from arrival at the trauma centre to emergent percutaneous procedures varied widely. Improved processes emphasizing patient transition from the trauma bay to the angiography suite are essential. Discussion regarding the appropriate time to angiography is needed so this marker can be used as a quality outcome measure for all level 1 trauma centres.

Contexte : De nos jours, en traumatologie, les soins reposent largement sur des interventions non chirurgicales percutanées d'extrême urgence, particulièrement chez les patients blessés à la rate, au bassin et au foie. Malheureusement, les indices de qualité spécifiques (p. ex., temps écoulé entre l'arrivée et l'angiographie) n'ont pas fait l'objet de discussions approfondies. Notre objectif était de mesurer le temps écoulé entre l'arrivée et l'instauration des interventions percutanées d'extrême urgence chez les grands blessés.

Méthodes : Tous les grands polytraumatisés (indice de gravité des blessures [IGB] > 12) amenés dans un centre de traumatologie de niveau 1 (2007–2010) ont fait l'objet d'une analyse au moyen d'une méthodologie statistique standard.

Résultats : Pour 60 patients gravement blessés (IGB moyen 31, hypotension 18 %, mortalité 12 %), le temps écoulé avant l'instauration d'une intervention angiographique a été de 270 minutes. Parmi les interventions effectuées, 85 % ont été des embolisations thérapeutiques et 15 % des interventions diagnostiques. Les embolisations spléniques (temps écoulé médian 243 minutes, intervalle 32–801 minutes) et pelviennes (temps écoulé médian 278 minutes, intervalle 153–466 minutes) ont représenté 43 % et 25 % des interventions, respectivement. La durée médiane de l'intervention d'embolisation dans le cas de la rate a été de 28 (intervalle 15–153) minutes, contre 59 (intervalle 34–171) minutes pour les blessures touchant le bassin. Près de 22 % des patients ont eu besoin d'une intervention percutanée d'extrême urgence et d'une intervention chirurgicale par la suite. Les explorations chirurgicales ouvertes ont généralement été précédées d'un traitement percutané.

Conclusion : Le temps écoulé entre l'arrivée au centre de traumatologie et les interventions percutanées d'extrême urgence varie beaucoup. Il faut, sans contredit, améliorer les processus en soulignant l'importance du transfert des patients de la salle de traumatologie à la salle d'angiographie et poursuivre la discussion sur le temps écoulé avant l'angiographie pour que ce marqueur puisse servir comme paramètre de mesure de la qualité dans tous les centres de traumatologie de niveau 1.

Most preventable deaths from trauma are a consequence of untreated hemorrhage and subsequent early exsanguination. Treatment modalities range from minimally invasive percutaneous techniques to invasive open procedures.

Angiography has emerged as a vital adjunct in the resuscitation of injured patients.[1] As a tool in the armamentarium of trauma care, the role of interventional radiology is no longer purely diagnostic, but instead has evolved into a predominantly therapeutic endeavour.[2] Modern trauma care relies heavily on nonoperative, emergent percutaneous techniques in the management of injured patients with substantial hemorrhage, particularly in patients with splenic, pelvic and hepatic injuries.[3–17] Furthermore, the American College of Surgeons Committee on Trauma states that both level I and II trauma centres should have timely availability to conventional angiography and to radiology staff with the ability to oversee therapeutic procedures.[18]

Unfortunately, general consensus guidelines are not currently available to define "timeliness" for percutaneous procedures aimed at hemorrhage control. This contrasts both neurologic (stroke) and cardiac (myocardial infarction) sciences, where strict time-based protocols have been in place for years.[19,20] Furthermore, these guidelines act as important quality metrics.

The primary objective of the present study was to evaluate the waiting time from patient arrival to initiation of any urgent percutaneous procedure in severely injured patients at a level I trauma centre. The secondary goal was to define the type and pattern of percutaneous interventions.

Methods

We identified all severely injured patients (injury severity score [ISS] ≥ 12) presenting to the Foothills Medical Centre (FMC) between Feb. 1, 2007, and Jan. 31, 2010. The FMC is a Trauma Association of Canada–accredited, level 1 trauma centre serving as the trauma referral facility for southern Alberta, southwestern Saskatchewan and southeastern British Columbia. As a result, more than 2 million people with severe injuries receive care at our centre, which admits more than 1100 of these patients anually. The Alberta Trauma Registry provided data on all patients (age, sex, comorbidities, date of injury, mechanism of injury, length of hospital and ICU stay, type of injuries, ISS, discharge destination, operative and percutaneous procedures, vital signs and mortality). Fidelity was ensured by additional searches of the Alberta Health Services electronic patient medical records; we obtained the waiting times and specific details for all percutaneous procedures from these medical records. The FMC angiography suite is located only a few metres from the trauma bays. We defined hypotension as persistent (at least 2 measurements < 90 mm Hg, measured at any point in the presurgical/angiographic care of the patient [i.e., prehospital or trauma bay]). These hypotensive measurements were taken at a mean interval of 16 minutes. This study was approved by the University of Calgary institutional review board.

Statistical analysis

All analyses were performed using Stata version 12.0 (Stata Corporation). Normally or near-normally distributed variables are reported as means, and non-normally distributed variables are reported as medians. We compared means using the Student *t* test and medians using the Mann–Whitney *U* test. We assessed differences in proportions for categorical data using the Fisher exact test. We considered results to be significant at $p < 0.05$.

Results

A total of 60 injured patients underwent urgent percutaneous procedures between Feb. 1, 2007, and Jan. 31, 2010. Patient, injury and outcome characteristics are summarized in Table 1. Blunt mechanisms accounted for most (94%) injuries (motor vehicle crashes 65%, falls 22%, assault 7%). Urgent percutaneous procedures were primarily therapeutic, with splenic and pelvic injuries representing the dominant targets (Table 2).

The overall median time from patient arrival to urgent percutaneous procedure was 270 minutes. The median time for urgent percutaneous procedures involving splenic and pelvic arterial embolizations was 243 and 278 minutes, respectively. The median procedure time of splenic embolizations was 28 minutes, while the median duration of pelvic embolizations was 59 minutes. Eleven (18%) injured patients requiring an urgent percutaneous procedure

Table 1. Patients demographic characteristics and outcomes

Characteristic	No. (%)*
No. patients	60
Age mean (range) yr	36 (15–84)
Male sex	50 (73)
ISS	31
Hypotension at admission (sBP < 90 mm Hg)	11 (18)
ICU admission	31 (52)
ICU stay mean (range) d	7 (1–24)
Mortality	7 (12)
Discharge status	
Home	30 (50)
Rehabilitation	23 (38)
Analyte	
pH	7.26
Base deficit	–7
Lactate, mg/dL	2.4
Massive transfusion protocol employed	5 (8)
CT before angiography	57 (95)
Mean RBC transfusion units < 24 h	1.4
Mean crystalloid resuscitation, L < 24 h	4.45
Referred from a preceding centre	14 (23)

*Unless otherwise indicated.
CT = computed tomography; ICU = intensive care unit; ISS = injury severity score; RBC = red blood cells; sBP = systolic blood pressure.

Table 2. Emergent percutaneous procedures	
Procedure	No. (%)
Percutaneous	
Diagnostic	9 (15)
Therapeutic	51 (85)
Therapeutic target organ	
Spleen	26 (43)
Pelvis	15 (25)
Other	10 (17)

presented to the hospital with a systolic blood pressure (sBP) less than 90 mm Hg. The median time to percutaneous procedure in this group of patients was 212 minutes. The rest of the injured trauma patients with an sBP greater than 90 mm Hg had a median time to percutaneous procedure of 259 minutes. Of the patients who presented with hypotension, 8 (73%) responded to fluid resuscitation. The median time to angiography in this subset was 253 minutes. In those who did not respond but who were transferred to the angiography suite (i.e., instead of directly to the operating theatre), the median door to needle time was 49 minutes.

Door to needle times were longer between midnight and 7 am. The overall mean time to percutaneous procedure from 7 am to 5 pm was 299 minutes. This compares to 298 minutes for procedures between 5 pm and midnight, as well as 357 minutes for angiography between midnight and 7 am (p = 0.041).

Thirteen (21.7%) injured trauma patients required both an emergent percutaneous and a subsequent open operative procedure. All patients except 1 underwent the percutaneous procedure before the operative intervention (the exception involved preperitoneal pelvic packing followed by embolization). The median time from the percutaneous procedure to the operative intervention in these patients was 2 days. This cohort includes 2 (7.7%) patients who initially underwent splenic artery embolization, 7 (50%) who received pelvic embolization, 1 who underwent internal mammary artery embolization (associated sternal fracture that eventually required a median sternotomy to decompress a mediastinal hematoma) and 1 who received an axillary artery embolization (axillary artery transection that was subsequently treated with an axillobrachial bypass). Patients undergoing splenic artery embolization and operative intervention had a median time of 4 days from the percutaneous procedure to operation. It should be noted that 1 patient underwent repair of a complex acetabular fracture while the other patient had a delayed repair of a missed diaphragmatic injury. The patients undergoing pelvic embolization and subsequent operative intervention also had a median time of 4 days from the percutaneous procedure to operation. All but 1 patient underwent orthopedic fixation of their pelvic fractures after embolization at the discretion of the orthopedic surgery service.

Discussion

Our study reveals a wide range in waiting times for urgent angiographic procedures in severely injured patients presenting to our trauma centre. It also represents the first time, to our knowledge, that a tertiary referral trauma centre has audited the overall timeliness of obtaining urgent percutaneous procedures in potentially hemorrhaging patients with all types of injury patterns. Although a select few North American centres have suggested local door to needle response times, there is no commonly agreed upon target threshold or quality measure. This fundamentally differs from neurologic and cardiac sciences (90 min). It is also problematic given that delays in angiography have been shown to lead to a 2-fold higher risk of death in injured patients (47% increase with each hour of delay).[21]

While there is a paucity of literature surrounding overall door to needle times, reasonable data exist with regard to pelvic fractures. Tai and colleagues,[22] commented that retroperitoneal pelvic packing was as clinically effective as angiography and significantly reduced the 140-minute delay to achieving embolization. Similarly, Osborn and colleagues[23] noted a reduction to hemorrhage control within 45 minutes for pelvic packing compared with 130 minutes for angiography. Finally, although door to needle times are inadequately discussed, Cothren and colleagues[24] also advocate routine peritoneal pelvic packing with a combined operative and subsequent angiography time of 164 minutes. It is interesting to note that although these delays appear much shorter than our overall pelvic fracture door to needle times (median 278 min), the mean time for patients with pelvic fractures and concurrent hypotension that was not responsive to resuscitation in our audit was only 41 min. Certainly the slower percutaneous response times between midnight and 7 am noted in our centre reflect a need for improvement.

We hypothesize that the wide range in waiting times for obtaining emergent percutaneous procedures for injured patients is multifactorial. Clearly a substantial proportion of this time involves activation of the interventional radiology team comprising a radiologist and 2 nurse specialists/technicians. Although the trauma team is onsite 24 hours per day, the door to decision time is entirely under the control of the attending trauma surgeon. This clearly represents an important factor in potential delays and may include variables such as waiting for computed tomography (i.e., to detect vascular extravasation in a hemodynamically stable patient), evaluating a patient's response to ongoing resuscitation and/or individual surgeon experience and training. Unfortunately, the precise time point at which a trauma surgeon makes the decision to proceed to angiography is not possible to discern in a retrospective audit. Because the door to needle time remains a very crude quality measure, our future prospective study will capture all potential details, including what we believe may be the most important factor: door to decision time.

The subset of injured trauma patients requiring both an emergent percutaneous procedure and an operative intervention requires special mention. Given the liberal access to interventional radiology procedures at our institution (both geographically and personnel-wise), injured patients with splenic and/or pelvic trauma are typically selected on an aggressive basis to undergo emergent embolization. As outlined, there were no observed failures in splenic or pelvic embolizations that required a subsequent operative procedure. Lone "failures" were related to an eventual mediastinal hematoma after an internal mammary arterial laceration and a vascular bypass after arrest of axillary hemorrhage with embolization.

To further improve the response times for obtaining emergent percutaneous procedures in severely injured patients, the concept of a single, hybrid operating suite is becoming more popular. This technology allows emergent percutaneous interventions to be performed in the same physical location as open procedures, resuscitations, general anesthesia and critical care. This advanced resuscitation with angiography, percutaneous techniques and operative repair (RAPTOR) suite would prevent timely delays in transporting injured patients between the trauma bay, operating theatre and/or interventional radiology suite.[25]

A benefit of this study will be the ability to use waiting times as a quality metric for the performance of our trauma and radiology teams as well as for the planned implementation of the RAPTOR suite. Furthermore, we hope to use these door to needle metrics in future iterations of the Trauma Association of Canada's trauma centre accreditation process.

Conclusions

To our knowledge, this is the first formal audit of waiting times for obtaining all urgent percutaneous procedures in severely injured patients. Despite the effectiveness of therapeutic angiography, wide variations in waiting times remain problematic. This data has served as an initial foundation for a prospective waiting time tracking study that we hope can be used as a quality benchmark for both continuous quality improvement and evaluation of the RAPTOR suite.

Competing interests: None declared.

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