

Missed injury – decreasing morbidity and mortality: A literature review

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Summary

This brief literature review examines the causes of missed injury, the typical clinical pictures that are associated with missed injury and techniques and procedures to help avoid missing injury in the light of the recent literature, while highlighting the cost implications for clinicians.

Missed injuries are defined variously as injuries identified after the initial period of resuscitation (primary and secondary survey of Advanced Trauma Life Support[®]), although they may also be injuries identified after a defined time period after injury, such as 12 or 24 hours.^{1,2} However, there is no absolute definition, since some missed injuries may present long after the traumatic event (e.g. penetrating injuries of the diaphragm presenting many months to years later as a hernia).

Missed injury has been a source of concern to clinicians for many years, and the first series examining the influence of missed injury from South Africa was reported by Gordon in 1986.³ While missed injury is not new, what is surprising is that injuries are missed even in developed countries with experienced units.^{2,4}

Incidence

Why make such an issue about missed injuries? Missed injuries occur with a remarkable degree of regularity in recognisable patterns, with the same or similar patterns of injuries being missed repeatedly in most reported series from around the globe.

Looking at South African original publications on missed injuries, the first, from 1986, examined missed injuries in children in a newly developed paediatric trauma unit and detected a 2.5% incidence in the children admitted to the wards, whereas only 0.3% of children 'treated and released' were found to have a missed injury.³

Muckart and Thomson⁵ subsequently reported their experience with torso trauma from KwaZulu-Natal, finding a 2.6% missed injury rate for penetrating trauma and a 4% rate for blunt trauma. They noted that the consequences were grave, with a 44% mortality rate overall for this subgroup, which increased to 88% if the missed injury was missed at urgent surgery.

Depending on the definition of missed injury, the incidence varies from around 1.3% to as high as 39%.⁶⁻⁸ Most commonly there is a human factor involved in the misdetection of the injury.⁹ Of all missed injuries identified, the sub-group that requires a change in management (i.e. clinically significant injuries) is between 15% and 22% of the total.^{6,7}

More recently, Clarke and co-workers from Pietermaritzburg presented their experience, also reporting a 2.5% incidence, but

attempting to classify the cause of the misdiagnosis. They found that 41% of missed injuries were due to inadequate clinical assessment, while 32% were due to errors related to imaging (wrong investigation or misinterpretation), thus implying that 73% were due to human error.¹⁰ One further study examined technical issues around chest drains, but this was not directly related to missed injury; rather misplaced or incorrect technical methods were identified, with the potential for iatrogenic injury.¹¹

The true incidence of missed injury in South Africa is unknown, because we have only local databases and no comprehensive trauma registries; many of the former are paper based and therefore less robust than electronic databases. The Trauma Society has attempted to rectify this by establishing the Trauma Bank database, but uptake has been variable.

A number of recent international studies on the subject have been identified. These include a review of the largest patient cohort to date from the Los Angeles group in the USA,¹² where 35 000 patients were reviewed. Of these 1% had a complication identified. Only 14% of these complications (58 patients) were due to a missed injury; however, 64% necessitated a management change. This highlights the low level of missed injury in a modern, level 1 trauma centre in a developed country.

Malhorta *et al.* from Virginia examined 1 353 trauma patients and had a 50% follow-up rate at 4 weeks after injury (692 patients).¹³ In this follow-up group they identified only 17 patients with a missed injury that required medical intervention, i.e. 2.5% of the follow-up group, in keeping with previous publications.

Finally, Ekeh and colleagues examined the incidence of missed injury to the aortic arch when plain film radiography of the chest was compared with computed tomography (CT) scans, and found that there would be an 11% missed injury rate when relying only on the chest film.¹⁴ This leads to the conclusion that better screening tests, such as trauma CT, are recommended for patients with blunt chest trauma, even if the plain film is normal. Interestingly, 50% of the controls in their study with a normal aorta had an abnormal plain radiograph, again demonstrating the poor sensitivity of this test.

Which injuries are missed?

Missed injuries can be detected across the entire spectrum, but there appear to be certain groups of injuries that are more likely to be overlooked or remain unsuspected.

Cervical spinal injuries continue to be overlooked or missed, due to inadequate clinical assessment, inadequate imaging, or not evaluating abnormal films with further imaging, both of the injury and the rest of the spine.¹⁵ Fortunately the majority of these injuries are stable injuries with no adverse sequelae.¹⁶ Thoracic or lumbar

spinal fractures are missed due to inability to do a proper clinical examination, and a low threshold to image these regions should be maintained.¹⁷ CT is regarded as the gold standard, for both adults and children.^{18,19}

Chest injuries that are often missed or underestimated include pneumothorax or haemothorax, missed when the imaging is undertaken early after injury or where the clinical picture gradually evolves, for example with progression of pulmonary contusion. Older patients are at an increased risk of having a chest injury underestimated.²⁰ Other chest injuries that may be overlooked include diaphragm injury (particularly penetrating injuries), aortic injury when the initial chest film is reported as normal, and occasionally missed penetrating cardiac injury.¹⁶

The abdomen is another area of concern, since blunt small-bowel injury may be masked by a decreased level of consciousness, lack of initial abdominal signs, and other distracting injuries.²¹ Small-bowel and pancreas injuries are more common when a liver injury is present.²¹ The concept of the solid organ injury that 'has bled' and has now stabilised, allowing for selective non-operative management, is well established. It is recognised that there is a higher incidence of delayed diagnosis of bowel injury in this group, with a higher morbidity but no statistical increase in mortality.²² There is a need for increased vigilance in this group of non-operatively managed patients.

The other areas of concern in the abdomen are the retroperitoneum and the ureters, which are often not visualised with penetrating injury and may only be diagnosed appropriately with imaging studies. Included with the abdomen is the perineum, another area where injuries may be missed, due to inadequate removal of clothing or through avoidance of rectal or genital examination. Missed injuries here lead to high rates of sepsis.²³ The consequences of missed abdominal injury are devastating, with the need for admission to an intensive care unit (ICU), multiple re-laparotomies, the risk of multiple organ dysfunction or failure and prolonged hospital stay for survivors, while the mortality of abdominal sepsis remains high at around 25%.^{16,22,23}

Up to 50% of all missed injuries in a number of studies have been reported as occurring in the extremities and other bony tissue.^{6,7,24} Injuries that are easily overlooked in the rush of the resuscitation phase are those to the small bones of the hands and feet, to ligaments (particularly knee dislocation), and to the facial bones. These should be actively searched for in the post-resuscitation period.

Neurovascular injuries that are missed are of particular concern as they may lead to avoidable limb loss or even loss of life. These injuries often occur in compromised patients (head or spinal injury) who are difficult to evaluate. Blunt cervical vascular injury with resultant stroke, peripheral nerve deficits and undetected compartment syndrome occur in this patient group, and close clinical observation and liberal fasciotomy are invaluable.

Less commonly, myoglobinopathies and renal failure ('crush syndrome') occur when soft-tissue injury or reperfusion injury are underestimated. Risk groups include those who have been assaulted with blunt objects ('sjambok injury') or those with blunt multiple injury. Liberal screening with serum creatine kinase or urine myoglobin will prevent renal impairment.²⁵ Adequate fluid resuscitation will avoid the complications.

Foreign bodies may be missed by inadequate imaging (glass) or through deliberate concealment (criminal activity) and may be a

source of later litigation. Finally, other underlying disorders may mask clinically relevant findings or may be inadvertently identified after trauma with resultant potential for inappropriate intervention on the assumption that it is a traumatic injury (e.g. a stab wound of the neck with an abnormal contrast study that turns out to be achalasia).²⁶

Why are injuries missed?

The reasons for injuries being missed are complex and multifactorial. The high levels of diagnostic uncertainty associated with emergency patients, the need for time-dependent decision making, multiple care providers and surrounding distractions all increase the chances of missing injuries. Numerous handovers of care also result in loss of information. The quality of the system in which the provider is working also influences the risk of missing an injury.²⁷ All of these factors lead to a lack of 'dual-process' thinking – an imbalance between protocol and common sense, for example not following a particular line of investigation as per protocol because there are other distracting injuries or competing priorities.

Mis-triage occurs where older and very young patients are difficult to assess, when clinicians lack experience or skills, such as limited ATLS training and lack of trauma nursing skill, or in the presence of mainly junior staff, as is typical in many of the rural hospitals in South Africa. System issues include rural hospitals not referring appropriate patients timeously, or a delay in availability of blood results, radiology results and other investigations. In South Africa, cost containment plays a very definite role, such as not doing a test to save money when the test is clinically indicated. However, this can never be a justifiable defence in a claim for damages incurred through inadequate testing.

When all the above are viewed as intertwining concentric circles with multiple interplay, several factors can be identified, both internal and external, that affect error occurrence in a care system.²⁸ These include patient factors, technological factors, the health worker's physical and emotional state, ambient climatic and working conditions, the physical structure of the facility, social, legal and cultural influences, and finally the quality of the hospital organisation.

Clarke *et al.*¹⁰ have devised a taxonomy for missed injury, and Thomson and Greaves⁷ have proposed a standard reporting system for missed injuries – both are valid and highly recommended for practice quality assurance.

What are the consequences of missed injuries?

Fortunately, most missed injuries are unlikely to cause significant morbidity or mortality. These injuries do not usually prolong ICU stay,²¹ although limb injuries may decrease long-term quality of life. In most cases the higher mortality is related to the severity of other readily identified injuries rather than missed injuries. Although as many as 30% of injuries may be considered 'significant', few (<2%) are lethal.¹⁵ One recent autopsy study revealed that 6.5% of deaths were attributable to missed or delayed injury diagnosis.²⁹ Pfeifer and Pape, in a meta-analysis of 17 studies, state that there was an equal mix of minor and major missed injuries, with a very low (1 - 4%) incidence of life-threatening complications.⁶ The fact that health care is expensive, particularly in the light of the planned National Health Insurance,³⁰ and the cost of litigation is increasing, should lead to awareness of and vigilance regarding missed injury.

How do I avoid missing injuries next time?

Croskerry²⁷ advises that reducing dependence on memory by written protocols, regular review of the patient in context (what he calls 'metacognition'), and optimising the local treatment environment can decrease clinical error. The use of clinical decision nodes and feedback loops will enhance this review process. One example pertinent to the trauma patient is known as the Tertiary Trauma Survey, first described by Enderson in 1990.²

The Tertiary Trauma Survey^{2,6,7}

This concept is outlined in terms of the frequently asked questions pertinent to the topic.

First, why perform a Tertiary Survey? A significant proportion of delayed diagnoses are radiology related, with some of the results only available after the secondary survey is complete. About 6% of these injuries will require surgical intervention, or other changes in management.

Second, what does the Tertiary Survey comprise? It should include a complete review of the patient's clinical findings and incorporate all body systems, a review of all radiology and blood results and a review of all procedural interventions that have been performed during the resuscitation and definitive care phases, so as to allow for determination of further care plans.

Third, who should be screened with a Tertiary Survey? Ideally all trauma patients should be reviewed in this way, although outpatient studies have determined that the missed injury rate is usually <1% for patients discharged home after initial assessment, so the risk is reduced in this patient cohort. Certainly all admitted patients should be included, especially those admitted to an ICU.

Fourth, when is a Tertiary Survey performed? Recommendations are that it should be done either on arrival in the ICU or after 24 hours after admission to a ward, as this gives time to get all the relevant documentation and allows the resuscitation phase to be completed. It can, however, be performed on an outpatient basis, although the stated risk is lower for these patients.

Finally, how does a Tertiary Survey proceed? The most important concept of the Tertiary Survey is that it is a team-based review, which should include at least one unbiased senior staff member, preferably not previously involved with the case. In the context of blunt trauma it is also ideal to have orthopaedic input because of the high rate of missed musculoskeletal injury. It has been demonstrated that the Tertiary Survey is more useful in blunt than penetrating trauma, since the operative indications are often more clearly defined in the penetrating trauma subgroup.

Conclusion

In summary, to err is human, so missed injuries are not an embarrassment. However, although no witch hunts should be instigated when injuries are missed, continuous audit is essential in preventing repeated errors! Missed injuries will occur, so one must actively investigate to find them, as such injuries may delay healing or cause multiple-system compromise. Deal with these injuries rapidly once they are identified, as they can increase morbidity and mortality. Develop suitable systems to improve care so that missed injury is minimised, otherwise the risk remains that litigation may follow.

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