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TRAUMA Grapevine

Contents:

Introduction

As we progress towards the middle of 2005, we leave behind one of the more progressive years trauma care has seen in Australasia. So many diverse advances in clinical care, research and education. The continued development of trauma services with reviews completed in Western Australia, and the Northern Territory. There has been additional appointment of trauma surgeons in Adelaide, John Hunter and Brisbane. The organisation of complete services, focusing on data and nursing care in NSW by ITIM has been impressive and welcome.

Future challenges lie in the delivery of consistent specialised trauma care round the clock. To achieve this patients and staff will need the support of Trauma Surgical Services at major trauma centers. This will require additional trauma surgical appointments. Liverpool Hospital's recent appointment of its third trauma surgeon, Dr Grant Christey, will facilitate, but not complete this cover. Major Trauma services are going to require a team of at least 5 Trauma Surgeons with support from some general surgery colleagues. To realistically achieve this trauma will need to be concentrated in fewer centres. It is not surprising therefore that current Trauma Directors in NSW feel major trauma patients should be brought to at the most three trauma centres in Sydney.

When a trauma service can provide a dedicated Trauma surgical team, encompassing all specialties working towards the same goals and targets, this will result in reduction in avoidable mortality from 24% to 10%.

The future therefore is exciting, for all trauma care providers and our patients. This issue of the Grapevine will delve into the issue of early management of trauma looking at liver injury and the important issues of ladder injuries.

Michael Sugrue

BLUNT HEPATIC INJURY: Strategies for Diagnosis and Management

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Introduction

Despite its relatively protected location, the liver is the most frequently injured intra-abdominal organ.[1] The past two decades have seen a dramatic shift in the management of haemodynamically stable adult patients with hepatic injuries, where non-operative measures have become the accepted standard of care. As a result, it has become increasingly important for surgeons and other clinicians to have detailed knowledge and experience with complex decision-making, diagnostic modalities and nonoperative interventions.

Epidemiology

The liver is injured in 35-45% of patients with significant blunt abdominal trauma.[2] The majority of these blunt hepatic injuries (BHI) are minor (AAST grades I and II)[3], requiring intervention infrequently. More complex hepatic injuries (AAST grades III-VI) constitute 10-30% of the population and can be more of a challenge to manage. At Liverpool Hospital, blunt trauma accounts for 79% of liver injury and penetrating trauma for 21%[4], a pattern mirrored in only one Australian series.[5]

Deceleration injuries (motor vehicle crashes and falls from heights) and direct blows to the abdomen constitute the two major mechanisms of injury.[6] The former usually produces disruption of the liver capsule and parenchyma at sites of attachment to the diaphragm and fractures often follow major hepatic venous branches. Extremely rapid deceleration may generate enough sheer forces to cause avulsion of hepatic veins from the inferior vena cava but these types of injuries are rare. Direct trauma by a blunt object may cause lacerations to the central portion of the parenchyma without disrupting the capsule.

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As most injuries are venous and minor, bleeding is usually self-limited. In more severe injuries, bleeding may continue and require significant resuscitation. These patients will often require surgery and some may require further interventions such as angiographic embolisation.

Diagnostic Modalities

All patients should be evaluated as per EMST (Early Management of Severe Trauma) (ATLS") protocols. The patient with trauma to the right upper quadrant, thoracoabdominal area or flank, presenting with hypotension and abdominal distention is considered high risk for having a major liver injury. However, 50-85% of patients with BHI will be haemodynamically stable or only mildly hypotensive.[2]

The unstable patient should have an early FAST (Focused Assessment with Sonography for Trauma) or DPA (diagnostic peritoneal aspiration, the initial aspiration of the peritoneal cavity on placement of a diagnostic peritoneal lavage catheter), followed by laparotomy if positive. DPA may be quick and easy to perform, but is generally reserved for haemodynamically unstable patients when FAST is not available. Its sensitivity lies in the detection of BHI that results in gross haemoperitoneum. However, reliance on the non-specific findings of DPA or DPL in stable patients may result in a nontherapeutic laparotomy rate as high as 48%.[7] FAST has the advantages of being rapid, non-invasive and can be performed fairly unobtrusively during the resuscitation. It is also easily repeated.

CT scanning is the gold standard imaging modality in haemodynamically stable patients. Not only does it allow anatomic delineation of the injury and some information on severity, it may provide information about other intraabdominal injuries. Much reference is made to the CT-based grading system by the AAST,[8] but its use in clinical practice has been limited by its poor correlation with injury severity at laparotomy. One study in 1991 showed that preoperative CT grading correlated with operative findings in only 16% of cases, and underestimated the injury in 41%.[9] Whether or not technologically improved scanners have improved this correlation is unknown, since most BHI are now managed non-operatively. Regardless, it is not the grade of injury that determines the path of management, but haemodynamic stability. Scans should be performed with intravenous contrast as the hepatic "blush" (demonstrating contrast extravasation or active bleeding) has an important bearing on management. The blush is an indicator of active bleeding, and there is a rapid and unpredictable haemodynamic deterioration in 67-75% of such cases.[10,11] Thus, its early detection is paramount for improving the success of non-operative management. If recognised early, rapid angiography and arterial embolisation may control active bleeding and the need for urgent surgery. Data on the accuracy of the CT blush and its management continues to emerge. Poletti et al[12] compared the accuracy of CT with hepatic angiography for active arterial bleeding in

In isolated liver injury, the most important factor in determining management strategy is the haemodynamic status of the patient.

2000 and showed that CT was 65% sensitive and 85% specific. The sensitivity fell to 56% when CT findings for active hepatic bleeding were compared with both surgical and angiographic results. In contrast, the blush in bleeding pelvic fractures has high sensitivity (80%) and specificity (98%), and is a reliable marker of the need for embolisation.[13]

In isolated liver injury, the most important factor in determining management strategy is the haemodynamic status of the patient. The stable patient is a candidate for non-operative management in selected situations, but it is essential to have access to computed tomography (CT) and this can only be done in centres where adequate surgical services exist.

NON-OPERATIVE MANAGEMENT

Historical Trends

Pringle concluded in 1908 that the only way to treat liver injuries was surgically. This predominantly operative approach to liver injuries has been held firmly by some surgeons as late as 1990.[15] Further reluctance to manage hepatic injuries non-operatively was supported by concerns of missing an associated injury and that lack of bile drainage would result in biliary fistulas and infective complications. It was found in the early 1980's that non-operative management was successfully employed in the paediatric population and that both spontaneous haemostasis and healing were possible.[16,17] Success rates as high as 90% were reported and this paved the way for sporadic reports of non-operative management in the adult population.[18,19] More than half of liver injuries were noted to have spontaneously stopped bleeding by the time of laparotomy 20, and up to 67% of these laparotomies were considered to be non-therapeutic. Lack of biliary drainage also did not appear to affect outcome.[21] The advent of CT scanning, with its increased availability and accurate definition of hepatic and non-hepatic injuries (the rate of missed intraabdominal injuries is 0.5-12% when CT is used[22-23]) has allowed surgeons to deviate safely from the time tested approach of early laparotomy.

Selection Criteria For Non-Operative Management

Having met the critical criterion of haemodynamic stability, some high grade injuries (up to 43% of grades III-V) can be managed non-operatively.[24] The following additional criteria should be met: absence of peritoneal signs or signs localized only in the RUQ, timely and precise CT scan delineation of the injury (with very experienced radiologists), absence of associated intra abdominal or retroperitoneal injuries on CT that require operative intervention, and absence of excessive hepatic related transfusions (usually limited to four). Most importantly, centres without intensive care facilities and access to 24-hour surgeon and operating theatres should not manage these types of injuries.

Transcatheter Arterial Embolization (TAE)

TAE is rapidly gaining support as an adjunct to management of BHI. Its role in rapidly and effectively controlling active splenic and pelvic haemorrhage has been well characterized.[25,26] The use of TAE for BHI was first recognized in the 1970s,[27] since then its use has increased from 1% to 9% over three decades.[28] TAE has the advantage over surgery of being able to accurately localise the site of active bleeding without the attendant risks of manual exploration. Success rates have ranged from 83 to 93%,[29-31] with some centres even reporting 100% success rates.[32,33] Most of the data however comes from small retrospective studies, with little indication as to the timing of use or predictors of failure. One study showed a trend towards lower morbidity and mortality when TAE was performed immediately after CT scanning, as opposed to following failed nonoperative management or following surgery.[30] The dual blood supply of the liver allows embolisation to be done with low risk of ischemic necrosis, however gallbladder infarction is not uncommon.[34] Most agree that TAE is the treatment of choice on detection of the CT blush, providing the patient is haemodynamically stable.

Monitoring

Failure of an initial non-operative approach can be as high as 7.5% (liver- and non-liver-related failures)[35] with fewer patients managed nonoperatively as grade of injury increases. Close monitoring of vital signs, repeated examinations and serial haemoglobin estimations are necessary to assess response to treatment. Acute haemodynamic decompensation, as seen with splenic injuries, is not typical of BHI. Rather, most patients will manifest continued bleeding as a gradual reduction in haematocrit. Therefore, close supervision allows early detection of failed nonoperative approach. Other clinical indicators

of failure include sudden development of abdominal pain, distention or upper gastrointestinal bleeding suggesting haemobilia. Certainly, an increasing transfusion requirement or deterioration in vital signs mandates urgent treatment (angiography with a view to TAE in the stable patient or laparotomy in the unstable patient). It is difficult to predict failure of nonoperative management by initial presentation or CT scans alone. An initial period of observation in an ICU setting can be useful until ongoing haemorrhage is excluded.

Routine follow-up CT scanning for low-grade injuries is largely considered unnecessary.[36,37] The clinical picture should guide the need for repeat imaging. Routine follow-up scans for high-grade injuries are contentious and there is a lack of evidence-based guidelines to assist in this regard.

Outcome

The success rates of non-operative management in properly selected patients has been excellent with 97.5% success rates[22,35,38] with most failures (66.6%) involving grade IV and V injuries.[22] Patients managed non-operatively have lower transfusion requirements, shorter hospital stay and lower mortality than operatively managed patients with similar injury scores.[35]

Delayed haemorrhage is the most common complication (0-3.5%),[39] and less than 20% of these require blood transfusion. Intrahepatic and perihepatic collections are infrequent with bilomas and bile leaks occurring in 3% and abscesses in 0.7%, and these can often be managed non-operatively also. Liver- related complications in general appear to be less frequent in patients who are managed nonoperatively. The low incidence of missed abdominal injuries on CT has already been mentioned, and these are mostly the result of inexperienced interpretation or poor quality images.[40]

Operative Management

Literature over the last decade has showed a trend towards parenchymal preserving procedures at laparotomy rather than aggressive techniques like hepatic resection. Packing and damage control are currently the favoured approach and the one that is taught in the Definitive Surgical Trauma Care (DSTC) course internationally. This approach is most appropriate when managing patients with haemodynamic instability, multiple injuries and/or ongoing hypothermia, acidosis and coagulopathy. Rapidity of haemorrhage control is critical. Prolonged attempts at surgical repair may adversely affect survival.[41] The most important initial step is manual compression of the actively bleeding liver. Thereafter, techniques employed depend on the extent of the injury, physiological condition of the patient and the surgeon's experience.

Perihepatic packing should be the first option for the majority of surgeons faced with severe liver injury. Its role in BHI has come full circle. Packing was rejected around the time of WWII owing to septic complications and apparent poor efficacy,[42] but has since re-emerged as the preferred technique in unstable patients, provided it is effectively achieved and subsequent removal of packs is done as soon as physiology normalises. It is currently used in 8 -16% of all liver injuries requiring operation.[28,43] When laparotomy is required for higher grade injuries (III-VI) packing is used in 60%,[43] and has likely contributed to the declining mortality from BHI. Packing can be effective as definitive treatment for severe bi-lobar injuries and even for retrohepatic venous injuries in some situations.[44] As part of damage control, packing allows temporary haemostasis and quick termination of laparotomy, allowing further resuscitation efforts to proceed in ICU.[45] Packs should be removed as soon as the patient is stable, and hypothermia, coagulopathy and acidosis have been corrected.

Anatomical hepatic resection for the trauma patient has come under scrutiny, due to mortality rates approaching 50%.[46] This is particularly the case when the surgeon is not sufficiently experienced in elective hepatic resections and the patient's physiology is severely deranged. Rarely, anatomical resection may be required. Significantly lower mortality rates (8.1%) have been observed when experienced hepatobiliary surgeons perform the resection,[47] leading some to suggest that there should be a dedicated liver team for severe liver injury. Resectional debridement of devitalised tissue is comparatively quick to perform and reduces the risk of postoperative sepsis, secondary haemorrhage and bile leakage.[48] Selective hepatic artery ligation, once popular, is now uncommonly employed as other measures are usually sufficient to curtail the bleeding. It may be

Anatomical hepatic resection for the trauma patient has come under scrutiny, due to mortality rates approaching 50%

justified in the unstable patient if packing fails and temporary hepatic artery occlusion at the portal triad is effective. Hepatorraphy, the placement of large mattress sutures to compress liver parenchyma and bleeding vessels, was one of the first reported successful techniques, but has become unpopular due to reported risks of tissue necrosis and septic complications.[1] Adjunctive techniques including fibrin glues and sealants have been reported[49] but their specific roles are yet to be adequately defined.

Retrohepatic Venous Injuries

Complex injuries that continue to bleed may necessitate early use of the Pringle manoeuvre (cross clamping of the portal triad). The technique is both therapeutic, as it allows control of haemorrhage while definitive treatment is undertaken, and diagnostic, as failure to control bleeding suggests a venous source.

Retrohepatic venous injuries carry high mortality rates (50-100%)[48] irrespective of operative management and pose a further technical challenge for the surgeon. Suspicion is high when the Pringle manoeuvre fails to control bleeding or the injury is discovered to extend to the bare area of the liver. Thankfully, these injuries are uncommon. Hepatic vascular isolation techniques are preferred to atriocaval shunting procedures. Survival rates with atriocaval shunts have been alarmingly low (0-8.9%).[50,28] Patients undergoing non-shunting techniques generally fare better, with 60% survival rates for perihepatic packing and 40% for direct approaches to the retrohepatic veins.[28]

Complications of Operative Management

Major complications include ongoing haemorrhage, intraabdominal abscess, bilomas and biliary fistulas. Ongoing haemorrhage as a result of inaccessible arterial bleeding may be amenable to adjunctive TAE.[51] TAE is particularly useful for regions deep within the hepatic parenchyma and can be performed in the OT (if facilities are available) or in radiology after packing as part of a damage control procedure. Additionally, arteriovenous fistulae and false aneurysms can be embolised.[52]

Intra-abdominal sepsis occurs in 12%.[53] Resectional debridement can be useful if sepsis is related to the presence of devitalised tissue[54] and early pack removal reduces risk of sepsis when packing is employed.[55] Most post-operative abscesses can be drained percutaneously under CT or ultrasound guidance[56,57,] but occasionally require operative management. Bile leaks (up to 8%, even higher with resection[50]) usually heal spontaneously if adequate drainage is

achieved.[58] ERCP may also be used in the situation of a prolonged bile leak or large volume drainage. ERCP can both define the site of leakage and facilitate fistula healing by sphincterotomy or temporary stent placement.[59]

Other complications of operative hepatic injury management include hyperpyrexia (up to 64%, due to resorption of devitalised tissue),[50] respiratory complications (51% of patients)[59], wound sepsis (7-29%)[59,60,] acalculous cholecystitis, and liver failure (rare).

Mortality

The overall mortality in BHI is 10%, with mortality rates ascribed to the liver injury itself of only 2%.[28] Uncontrolled haemorrhage and associated non-hepatic injuries are the cause of most of the early deaths.[21,61] Late deaths are mainly due to head injuries and sepsis. Mortality has dramatically declined over the last 25 years. This is likely multifactorial and would definitely include better overall ICU care of critically injured patients. More recent results with perihepatic packing and the use of TAE are important trends that may also play a role in this decline.

Conclusions

The management of blunt hepatic injury is continuing to evolve. Non-operative management has over the last two decades become the treatment of choice for the stable patient, but an expeditious abdominal CT is essential as is competent surgical assessment. Most concur that a blush demonstrated in the CT of a stable patient mandates angiography and embolisation. Currently the only indication for surgery in isolated blunt hepatic injury is haemodynamic instability, but even then the emphasis in initial operative management now lies in more conservative techniques such as perihepatic packing. Whether an operative or non-operative approach is taken, the role of interventional radiology is growing and is likely to influence future trends in the management of blunt hepatic injury.

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Case of the Month

Remember last issues case of the month? A young male with a direct injury to RUQ. Well obviously one would suspect a liver injury. In this situation a rapid CT is important as we are looking more and more to Angiography to stop hepatic arterial bleeding. This case highlights a similar patient

CASE HISTORY

29-year-old male presented to an urban emergency department following a motor vehicle collision (MVC). He was subsequently transferred to a major trauma service via helicopter.

M – Driver, high speed into stationary car

I – Head, right sided chest, compound fracture right hand

S – GCS 3 P 96 BP 120/80

T – Intubated, hard collar, 1 L of Gelofusine given at the scene, 2 bags of crystalloid dripping during transfer.

Primary survey:

A – Intubated, hard collar

B – Trachea midline; O2 sat 100%, RR 12, chest clear (R=L)

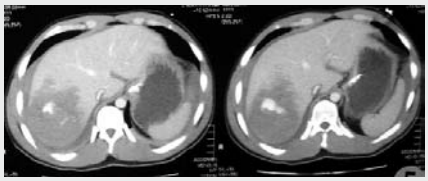
C – P 86 BP 124/72, blood oozing from nose and right mandible

D – GCS 3, right pupil 3mm, left pupil 2mm, reactive.

Secondary survey:

- Abdomen – non-distended, soft.
- Extremity – right upper limb complex laceration dorsum of hand, palpable 4th metacarpal fracture.

ABG: pH 7.16, pO^2 358, pCO^2 50, BE –11.

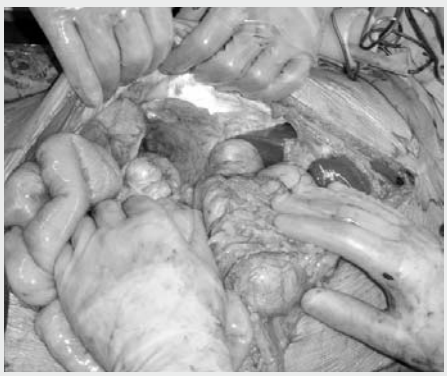


Treatment and Investigation:

- CXR, PXR both normal.
- Head and cervical CT showed no abnormalities.
- Neurosurgical and plastics registrars notified.
- Chest CT showed left sided pleural effusion and bilateral atelectasis. Abdominal CT showed a complex laceration of the right lobe of the liver involving segments V-VIII with a contrast blush and free fluid throughout the abdomen and pelvis.
- Inadequate information handover led to late determination of the following fluid administration:
- Scene: 1 L colloid
- Urban ED: 6 L crystalloid/colloid
- Transfer: 3 L crystalloid

Subsequently:

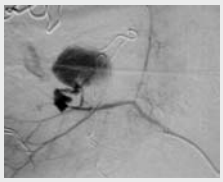
- Shortly after the abdominal CT the patient became hypotensive (PR 90, BP 90/50)
- Urgent transfer to the OT for laparotomy.
- Findings included 3L haemoperitoneum and a large grade IV hepatic laceration posteriorly mainly involving segments VI and VII. Liver packed achieving adequate haemostasis. Temporary abdominal closure.



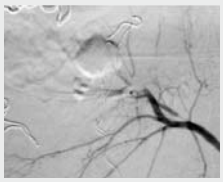
Perihepatic packing

Temporary abdominal closure

- Angiography organised based on CT findings (as noted above).
- Burr hole and insertion of EVD followed laparotomy. Towards end of neurosurgical procedure 700ml of bright red blood came down drains and systolic BP sagged to 75mmHg.
- The patient was taken to the angiography suite with successful embolisation of the bleeding vessel.



Pre-embolisation angiogram



Post-embolisation angiogram

Further management:

- ICU: rewarmed; coagulopathy corrected.
- Relook laparotomy on day 2 (no evidence of bleed), removal of packs and closure of abdomen.
- Maxillofacial and plastics undertook delayed repairs of facial and hand fractures.

Editorial Comment:

Trauma care requires attention to detail at all steps of care. Failure to, for example obtain an adequate handover may adverse effects. Remember to use the NEWS checklist. This case highlights the importance of haemortage control - In this case by angiography.

Meetings

Definitive Surgical Trauma Care Course (DSTC)

Liverpool: 27th and 28th July 2005
Charmaine Miranda 61 2 9828 3928

Auckland 1st and 2nd August 2005
Lyn Tucker 64 9 379 4949

Melbourne 22nd and 23rd November 2005
Lyn Journeaux 61 3 92767448

Military DSTC Sydney 26th July 2005
John Crozier 0418 469906

Melbourne 21st November 2005
Jeff Rosenfeld 61 3 92762683

SWAN 13

SWAN 13 will be held on the July29th and 30th, bringing to you a eight of world leaders in trauma care from overseas. Registration is limited, so get in early!

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Editorial Board

Remember if you are not a member of Australasian Trauma Society - you could be!

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The Impact of Falls From Ladders on Hospital Trauma Admissions

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Introduction:

Falls from height constitute a substantial proportion of a trauma services workload (Rozycki 1991). Ladders are widely accessible, and are used in both home and work environments. Hayward in 1996 showed ladders to be amongst the most dangerous of consumer products.

Falls from a ladder are associated with a wide spectrum of injuries. Isolated limb fractures are the most common injury, though serious head trauma, spinal injury and multiple fractures contribute to significant mortality rates (Partridge 1998). These injuries necessitate long stays in hospital and place a resource burden on a health service (O'Sullivan 2004).

Few studies have focused on the epidemiology of injuries caused by falls from a ladder and their prevalence. A clear understanding of the exact mechanisms of injury are useful in predicting pattern of injury, and in particular liaison with Health Promotions and Injury Prevention organisations is vital to reduce the overall prevalence of trauma. Falls from ladders are a potentially preventable form of injury. This study was undertaken to analyse the pattern of injuries resulting from falls from ladders in patients who were admitted to a major trauma service.

Methodology:

A retrospective registry review of all trauma patients admitted to Liverpool Hospital between January 2000 and December 2003 as a result of a fall from a ladder was undertaken. All patients falling between one and five metres from a ladder were eligible for inclusion.

Liverpool Hospital is the major trauma service for South Western Sydney serving a population of 750,000 people, and acts as a referral centre for the urban and rural hospitals within the region. It has a computerised registry into which trained data collectors have prospectively entered data.

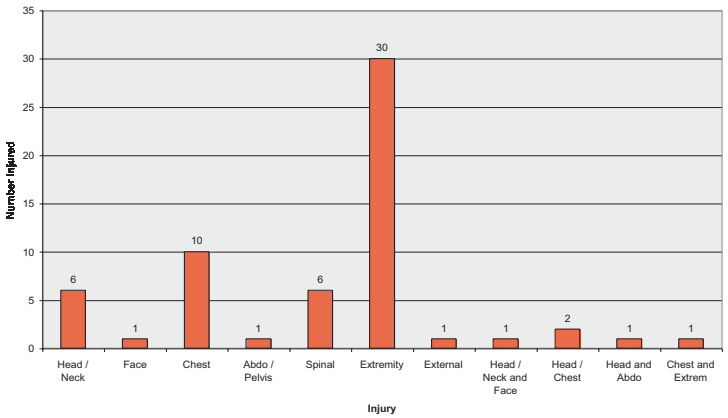
For all patients, demographics of age, sex, location of incident and mechanism of injury were collected. Injuries sustained were then classified as major trauma or minor injury according to the trauma registry protocol.

Principal injury diagnosis and length of hospital stay (days) were recorded for patients with minor injury. For major trauma category patients' ISS and individual AIS codes together with principal injury, length of ICU stay and length of hospital admission were analysed.

The data was reviewed to identify:

- Injury numbers and apparent patterns
- Height fallen
- Outcome of patient major / minor groups

Figure 1
Major Injuries sustained from 1-5m Ladder Falls
n = 61



Results

1. Demographics: 107 patients were admitted with injuries from ladder falls. The median age was 49.5 years (range 19 – 83). 89% of patients were male. 69% of accidents occurred at home and 21% at work (11% unknown location). The median length of stay was 5 days (range 1 – 44 days).
2. Injuries sustained: 61 (57%) of patients sustained major injuries whilst 46 (43%) were classified as minor injury. Two patients died. Three patients had consumed alcohol shortly before the accident all sustaining major injury.

Minor Injury Category

A wide range of minor injuries occurred. Isolated fractures of upper and lower limbs were the predominant injuries (36% ankle or foot, 30% upper limb). Other injuries seen included dislocations of the shoulder and knee, soft tissue damage, lacerations and tendon injury.

Major Injury Category

The median injury severity score was 9 (range 2 – 34). 50% of patients had predominant upper and lower limb injuries (figure 2). Other injuries included chest (15%), spinal (10%), head and neck (10%). Abdominal injuries were uncommon (2%). Seven patients had an ISS ≥ 16 (table 1).

ICU Admissions

Seven patients in total were admitted to ICU with a median ISS 14 (range 9 – 29). In this group, four patients sustained head injuries (subarachnoid haemorrhage, extradural haemorrhage, cerebral contusion and basilar skull fracture). One patient suffered multiple vertebral fractures. The remaining two admissions had multiple rib fractures and lower limb injuries.

3. Mechanism - Height Fallen and pattern of injury
   The trauma registry had no specific data field for height fallen. In a review of clinical comments from the database, approximate height fallen was specified in 17 (36%) of minor injury patients and 34 (57%) of major injury patients.

The pattern of minor injuries sustained in relation to height fallen demonstrated

10 limb fractures in falls under 3 meters. 2 Dislocated limbs occurred in falls between 2 and 4 meters. One patient fell over 4 meters and sustained only minor lacerations.

Major injury occurred in falls less than 2 meters with lower limb fractures being the most frequent injury.

Major injury occurred in falls less than 2 meters with lower limb fractures being the most frequent injury. A wide range of major injuries were observed in falls over 2 meters including three vertebral fractures (no cord disruption), one pelvic fracture and one simple pneumothorax. Four head injuries with an AIS code ≥ 2 occurred in falls between 3 and 4 meters.

4. Outcome - An overview of outcome is shown in figure 2.

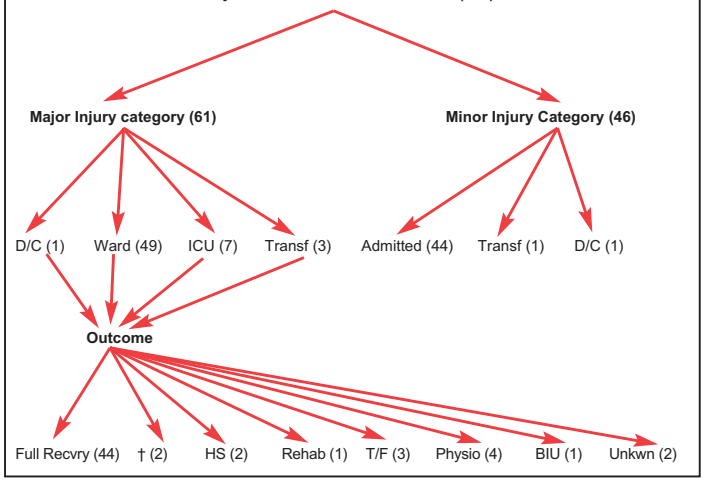
Minor Trauma

The median length of hospital stay in patients with minor injuries was 4 days (range 0 – 44). A 44-day admission was required for an elderly female who fell from less than 1 meter, sustaining a compound ankle fracture requiring multiple operative procedures.

Table 1
1 - 5 meter Ladder Falls with ISS ≥ 16

Pt	Age	ISS	AIS	Fell	Outcome
1	41	21	4 Head, 2 UL, 1Thorax	2m	Complete Recovery
2	80	29	4 Head, 3 Thorax, 2 Face	2m	Died
3	83	22	3 Face, 3 Thorax, 2 Spine	?	Died
4	41	21	4 Head, 2 UL, 1 Ext	3m	Brain Injury Unit
5	38	24	4 Head, 2 Face, 2 UL	2m	Complete Recovery
6	45	29	4 Head, 3 Thorax, 2 Face	?	Complete Recovery
7	63	16	4 Spine	?	T/f to Spinal Unit

Figure 2
Injured after fall 1-5m from ladder (106)



Major Trauma

A median stay of 7 days (range 0 – 38) occurred in major injured patients. Follow up data revealed 44 (73%) patients made a full recovery. Two patients died, one sustaining major head and chest injuries (ISS 29), dying 8 days post ICU discharge. The other patient sustained multiple vertebral fractures (ISS 22) and died in ICU 16 days later.

Of the remaining 14 (23%) major injured patients, two required home support following discharge (both male >50yrs with vertebral fractures). One patient (female 75yrs) required in-patient rehabilitation following a fractured neck of femur. Four patients attended multiple outpatient physiotherapy clinics (all with multiple fractures). Three Patients were transferred to other hospitals (two for tertiary spinal care and one elderly patient for convalescent recovery). One patient was admitted to the hospitals' brain injury unit following large cerebral haematoma and one patient with lower limb fractures self-discharged against medical advice after a 15-day ICU stay.

Four patients with ISS ≥ 16 did not require ICU care: one was transferred to a tertiary spinal unit and three head injured patients did not require intensive care or surgical intervention and were observed on a neurology ward.

Discussion

This study highlights falls from ladders as a mechanism of injury that continues to contribute a significant morbidity and mortality within the South Western Sydney population. The majority of incidents involved males (89%) aged 50yrs (median age) using ladders at home (69%). These demographic trends closely reflect previous study findings (Tsipouras 2001) and clearly indicate a subpopulation in need of specific education in accident prevention. 21% of incidents occurred at work despite increasing implementation of occupational health and safety standards (Australian Commission for Occupational Safety and Health, Annual Report 2003/4).

The trauma registry exclusively includes patients requiring admission to hospital. Injuries treated and discharged direct from the ED do not appear in this data set therefore understating the true prevalence of injury from ladder falls. The minor:major case mix (43%:57%) reflects Liverpool's role as a regional trauma centre accepting major trauma transfers from adjacent hospitals for definitive treatment.

A wide spectrum of injury pattern and severity are demonstrated after falls from ladders. Limbs are the dominant body region injured (66% of minor injuries and 50% of major trauma) consistent with findings of similar studies (Partridge 1998). This injury pattern is explained due to the mechanism described by patients, where an attempt is made to protect the rest of the body by outstretched limbs.

Patients with major injuries had a median ISS of 9, with life-threatening injuries including intracranial haemorrhage, pelvic fractures, spinal injury and pneumothorax. Patients with an ISS >16 were managed in ICU, observed on the neurosurgical ward after isolated head injury, or transferred for tertiary spinal injury care. The range of major injuries experienced strongly supports a multi-disciplinary approach to clinical management, which is achieved in Liverpool hospital by the provision of a trauma team and is complimented by a trauma transfer service.

Height fallen is inconsistently recorded in the trauma history (36% minor, 57% major). Though no absolute relationship can be determined between height fallen and pattern of injury sustained from this data, observations include fractures occurring frequently from falls of 1metre with major injury also possible from such heights. Head and vertebral injury are the significant causes of morbidity in falls from above 3 metres. One patient died as a result of injuries sustained from a fall of 2 metres. This information highlights the need for increased awareness of the risks of working at even minimal heights perceived by many as risk free.

Minor injury necessitated a median hospital stay of 4 days. Patients suffering major trauma spent seven days (median) in hospital with 73% making a full recovery. 20% of major injuries required follow up and further treatment within the health service. These outcomes have important implications when considering hospital resources with O'Sullivan 2004 indicating average costs of four thousand US dollars for a ladder fall hospital admission.

The exact mechanism of injury in ladder falls was difficult to define since the trauma registry has no specific data entry field. Information such as ladder type, reason for ladder use, weather and ground surface conditions and safety measures employed would be essential when considering an approach to accident prevention. This has highlighted the need for adjustment to clinical history recording and registry database entry methods to identify ladder falls and their specific mechanism. By limiting the criteria for falls between 1 and 5 metres ground-level slips and specialist high-access ladder techniques were excluded.

Conclusion

This study highlights the workload placed on Liverpool Emergency and Trauma Services due to falls from ladders. Falls from low heights are commonly responsible for serious injury resulting in long hospital stays, costly and protracted recovery and even death. Prevalence has if anything been underestimated by specific selection of this study group from a trauma registry. Further work is required to define the specific mechanism of injury and address the at-risk population with increased investment in safety education. As ever, the best treatment for trauma is prevention- Ladders need to be redesigned!

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