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Incidents During Out-of-Hospital Patient Transportation

A. FLABOURIS*, W. B. RUNCIMAN†, B. LEVINGS‡

NRMA CareFlight, N.S.W. Medical Retrieval Service, New South Wales and Intensive Care Unit, Royal Adelaide Hospital. Adelaide, South Australia, Australia

SUMMARY

Out-of-hospital patient transportation (retrieval) of critically ill patients occurs within highly complex environments. Adverse events are not uncommon. Incident monitoring provides a means to better understand such events.

The aim of this study was to characterize incidents occurring during retrieval to provide a basis for developing corrective strategies.

Four organizations contributed 125 reports, documenting 272 incidents; 91% of forms documented incidents as preventable. Incidents related to equipment (37%), patient care (26%), transport operations (11%), interpersonal communication (9%), planning or preparation (9%), retrieval staff (7%) and tasking (2%). Incidents occurred during patient transport to the receiving facility (26%), at patient origin (26%), during patient loading (20%), at the retrieval service base (18%) and receiving facility (9%). Contributing factors were system-based for 54% and human-based for 42%. Haste (7.5%), equipment malfunctioning (7.2%) or missing (5.5%), failure to check (5.8%) and pressure to proceed (5.2%) were the most frequent contributing factors. Harm was documented in 59% of incidents with one death. Minimizing factors were good crew skills/teamwork (42%), checking equipment (17%) and patient (8%), patient monitors (15%), good luck (14%) and good interpersonal communication (4%).

Incident monitoring provides sufficient insight into retrieval incidents to be a useful quality improvement tool for retrieval services. Information gathered suggested improvements in retrieval equipment design and use of alternative power sources, the use of pro formae for equipment checking, patient assessment, preparation for transportation and information transfer. Lessons from incidents in other areas applicable to retrieval should be linked for analysis with retrieval incidents.

Key Words: patient transportation, incident monitoring, patient safety

Medical care is delivered in "a dynamic environment with complex interactions between pathophysiologic and disease processes, medical staff, infrastructure, equipment, policies and protocols"[1]. Medical record review has shown that adverse events (incidents resulting in harm to a patient) occur in association with 10% of hospital admissions[2-4]. Patients most at risk are the elderly and those receiving urgent, complex interventions[2,3,6-8]. Medical record review, however, tells us little about how and why things go wrong[5]. Insight into the nature of these events and their contributing factors has come from a number of incident reporting systems, including those from critical care disciplines[9-15]. Such insight is necessary to devise preventive and corrective strategies.

Out-of-hospital patient transportation (retrieval), provides an even greater challenge as it occurs within a much more complex, dynamic, unpredictable and uncontrolled environment[16]. Retrieval involves patients with a severity of illness and observed mortality in excess of those for similar non-transported patients[17-19]. Adverse events such as hypoxia, hypotension, missed injuries, problems with vascular access, the airway, ventilation, and spine and limb immobilization have been documented during retrieval and are associated with increased patient morbidity and mortality[19-27]. Unresolved physiological instability prior to transport and lack of retrieval team experience contribute to these events, whilst correction of physiological instability prior to transport and the use of experienced retrieval teams reduces the severity of adverse events[28,29].

Medical retrieval also involves other emergency services and vehicle providers. Vehicle accidents

*F.J.F.I.C.M., PostGrad.Aviat.Med,, Staff Specialist, NRMA CareFlight, N.S.W. Medical Retrieval Service and Intensive Care Unit, Royal Adelaide Hospital.

†F.J.F.I.C.M., F.H.K.C.A., F.R.C.A., Ph.D., Professor, Department of Anaesthesia and Intensive C.are, Royal Adelaide Hospital and University of Adelaide.

‡National Data Development and Standards Unit, Australian Institute of Health and Welfare, Canberra, ACT.

Address for reprints: Intensive Care Unit, Royal Adelaide Hospital, North Terrace, Adelaide, S.A. 5001.

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during patient transport, although infrequent, can have serious consequences. Aeromedical emergency service accident rates peaked in the early 1980s at approximately 25 accidents per 100 000 flight hours[30] but more recently have been measured at 5 accidents per 100 000 flight hours[31]. The road ambulance accident rate is approximately 55 accidents per 100 000 transports[32].

The aim of this study was to set up incident reporting to collect and characterize problems occurring during retrieval and to identify their associated contributing and minimizing factors with a view to devising preventive and corrective strategies.

MATERIALS AND METHODS

A generic incident reporting form developed by the Australian Patient Safety Foundation (APSF)[33] for the Anaesthetic Incident Monitoring Study (AIMS)[6] formed the basis of the Retrieval Incident Monitoring Study (RIMS) incident report form.

Initially, transport medical records were reviewed from the NRMA CareFlight, New South Wales Medical Retrieval Service. In these records, retrieval medical staff voluntarily documented factors, in a free text format, that they considered to have impacted upon the course of a retrieval. Analysis of segments of this information has been reported elsewhere[16], and was used to develop the retrieval-specific section of the RIMS form and the RIMS incident classification system. Drafts of the RIMS form were circulated amongst participating organizations for final agreement.

Ethical approval was gained from the Western Sydney Area Health Service Human Research Ethics Committee.

Four retrieval organizations participated in the study. Two had teams consisting of a physician and a paramedic ambulance officer and utilized helicopter, fixed wing and road vehicles for a predominantly adult patient group. They were capable of rescue, 'scene response' (assessment and treatment at an accident or other out-of-hospital location) and patient transport from a scene or referring hospital. The third organization provided a paediatric/neonatal service, staffed by a physician and nurse, using helicopter, fixed wing and road vehicles for inter-hospital missions only. The fourth was staffed by flight nurses who conducted nurse only or nurse and physician missions using fixed wing aircraft.

Each organization nominated a project co-ordinator. The majority of clinical staff at each organization had prior exposure to incident reporting through their medical specialty (e.g. anaesthesia, intensive care, emergency medicine). Instructional packages and a sealed box for completed forms were provided to each site.

Identifiable information inadvertently included on the forms was deleted by APSF staff prior to data entry and analysis. All analysis was performed on the collated, de-identified data. This was to encourage reporting and preserve confidentiality, but did not allow for follow-up of missing data. Interim analysis of the collated data was provided as feedback to each organization midway through the study.

The free text was classified by two analysts, first independently and then following agreement. Other fields included on the form were those of incident severity, outcomes, prevention, minimizing and contributing factors. Aspects of the form have been described elsewhere[34]. The retrieval-specific incident categories are shown in Figure 1.

Descriptive analysis was used for all pre-coded items entered as ordinal data. Chi square analysis was used to assess the significance of the relationship, presence and absence of the different categories. Multinominal regression analysis was used to examine for the predictive factors under consideration. Significance was set at a $P<0.05$.

RESULTS

In all, 272 incidents were described on 125 incident forms: 62 forms (50%) described multiple incidents. In 30 forms (24%), the incidents described were not directly associated with patient care. The median age of the patients was 42.5 years (range 0.01—84 years), 54% were females and 64% were intubated and ventilated. Nine per cent of forms related to a scene response. For 117 forms (94%) where preventability was reported, 106 (91%) of the forms indicated the incidents to be preventable. Reporters were doctors for 67%, nurses for 32% and paramedics 1% of forms.

Figure 1 shows the principal incident categories and Tables 1-4 the nature of those incidents for the more frequent incident categories.

Mission planning and preparation problems occurred mostly at the retrieval service base (n=20). Retrieval service tasking problems included inappropriate choice of vehicle (n=3) and inappropriate decision to retrieve the patient (n=1).

Of the equipment problems, ventilator/breathing circuit problems (n=26) include breathing circuit disconnection, malfunction of unidirectional valve and failure of driving gas or electrical supply to the ventilator. Problems relating to vascular access (n=7) were mostly due to dislodgement of cannulae. Failure to provide oxygen cylinders, cylinder fittings and sufficient oxygen accounted for the oxygen supply

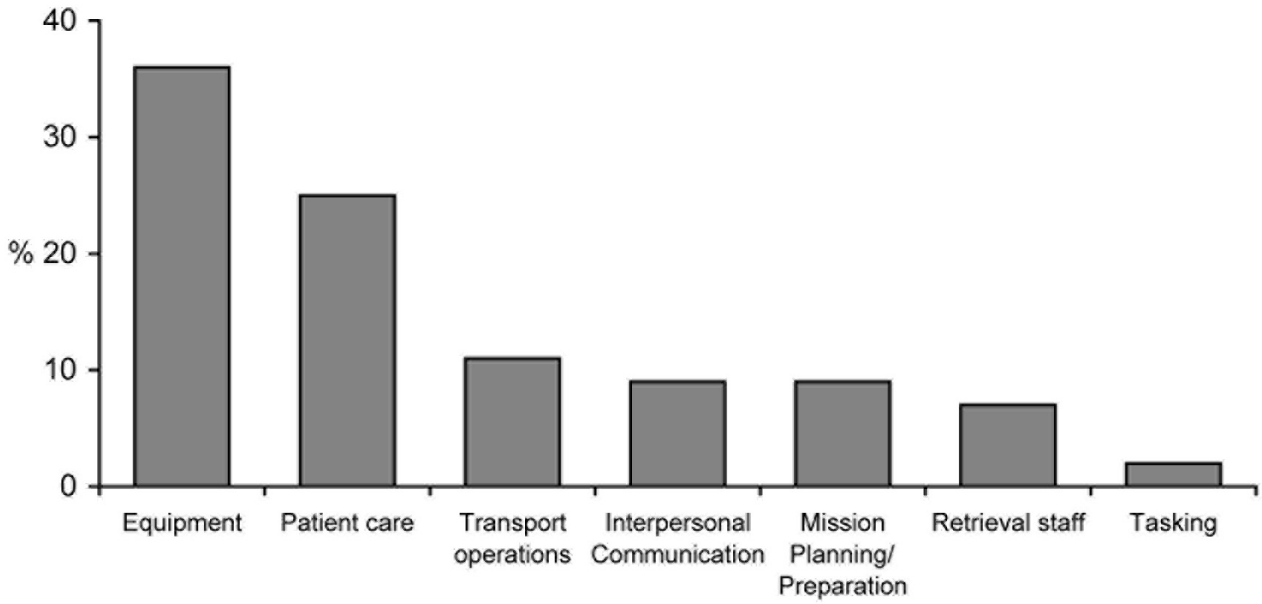

FIGURE 1: Incident categories.

TABLE 1
Nature of equipment problems

Equipment problems	No.	%
Equipment failure (including power)	37	38
Equipment unavailable	15	15
Breathing circuit, disconnection	8	8
Other	7	7
Oxygen not available	7	7
Vascular access dislodged/disconnected	7	7
Inadequate or inappropriate equipment	5	5
Damaged equipment	4	4
Safety equipment not available/inappropriate	4	4
Incorrectly secured equipment	2	2
Oxygen supply exhausted	1	1
Problem with communication means during transport	1	1

TABLE 2
Nature of patient care problems

Patient care problems	No.	%
Patients condition more severe than expected	15	22
Inappropriate or inadequate preparation at referring site	13	19
Hospital not prepared to receive patient	8	12
Deterioration of patients condition	7	10
Medication, dose/drug error	7	10
Inadequate patient preparation for retrieval	4	6
Procedure technically difficult to perform	4	6
Airway obstruction	3	4
Delay in decision to retrieve patient	3	4
Oesophageal intubation	2	3
Accidental extubation	2	3
Endobronchial intubation	1	2

incidents (n=6). None of the documented oxygen supply problems involved the transport vehicle on-board oxygen supply. Problems with powered medical devices were mostly those of failure/exhaustion of their power supply (n=15). Stretcher and/or

TABLE 3
Nature of transport problems

Transport operations problems	No.	%
Difficulty with patient transfer or loading	6	20
Problem with vehicle configuration for patient transport	6	20
Other problems relating to the vehicle	4	13
Delay in arrival/no ambulance to meet patient	3	10
Retrieval aborted or postponed due to weather	3	10
Aviation problem/problem with fuel/other problem	2	7
Problem related to landing site, not suitable	2	7
Other flying operations problems	2	7
Weather forecast unavailable/delayed	1	4
Vehicle failure/malfunction	1	4

TABLE 4
Nature of interpersonal communication problems

Interpersonal communication problems	No	%
Receiving hospital not made aware of patient's condition	7	28
Problem with staff communication	6	24
Inaccurate patient information from site	5	20
Staff unhelpful or uncooperative	4	16
Unprepared or incomplete referral documentation	3	12

stretcher lifting device (n=10) problems were due to malfunction or unavailability.

Patient care problems are listed in Table 2. They occurred mostly at the site of patient origin, prior to and following retrieval team arrival and at the receiving hospital. Patient care problems tended to be acute, unexpected, requiring intervention and technically challenging. Medication errors accounted for 10%, and the airway (accidental extubation, unrecognised oesophageal intubation and endobronchial intubation) 12% of all patient care problems.

Incidents involving retrieval staff were inexperience/

lacking appropriate skills (n=9), staff not available or delayed for mission response (n=6) and crew physical injury or exposure to chemical hazards (n=4), none of which required further medical attention. Injuries occurred during patient loading and to unsecured staff in a vehicle whilst accompanying a patient from the scene to the receiving hospital. Chemical hazard exposure was from a patient with organophosphate ingestion. There were also interpersonal conflicts (n=4), none of which involved violence, and failure to provide, or provision of inadequate, personal protective equipment (n=4).

Figure 2 illustrates the stage of the retrieval at which the incident occurred. Multiple stages were documented on 24 forms (20%). The patient loading incidents occurred at the time of departure from the site of patient origin.

Table 5 details the incidents relating to the type of retrieval vehicle. Eighteen forms (14%) were not associated with any transport vehicle use. Of the forms that documented incidents and the use of a transport vehicle, 28% of those forms involved fixed wing aircraft, 38% involved helicopters and 35% involved road vehicles. The type of transport vehicle had no relationship with incident preventability (P=0.577) or severity (P=0.642).

Eighty-six forms (69%) documented multiple contributing factors. Of all contributing factors, 54% were system-based (latent error, Table 6) and 42% were human-based (active error, Table 7) and 4% a chance event.

Incident outcome minimizing factors were documented on 99 forms (79%). These were good crew skills/teamwork (42%), re-evaluation of equipment (17%), re-evaluation of patient (8%), patient monitors (15%), good luck (14%) and good interpersonal communication (4%).

TABLE 5

Nature and number of incidents involving vehicles by type of vehicle

Fixed wing (n=30)	
• Difficulty with patient transfer or loading	6
• Problem with fuel	1
• Problem with vehicle configuration for patient transport	1
• Other flying operations problems	1
Helicopter (n=41)	
• Retrieval aborted or postponed due to weather	3
• Problem with vehicle configuration for patient transport	2
• Problem related to landing site	2
• Inappropriate vehicle chosen for task	1
• Weather forecast unavailable or delayed	1
• Other flying operations problems	1
• Problem with fuel	1
Road ambulance (n=37)	
• Other problems relating to the vehicle	4
• No ambulance to meet patient	3
• Problem with vehicle configuration for patient transport	3
• Inappropriate vehicle chosen for task	2
• Failure or malfunction	1

Patient or staff harm occurring as an outcome of the incident was documented in 59% of forms, whilst 92% of all forms documented a potential for harm. There was one patient death following an undetected oesophageal intubation. Availability and use of a capnograph was not documented.

Incident severity tended to be greater for the patient care (P=0.012), equipment (P=0.017) and planning and preparation (P=0.033) incident categories

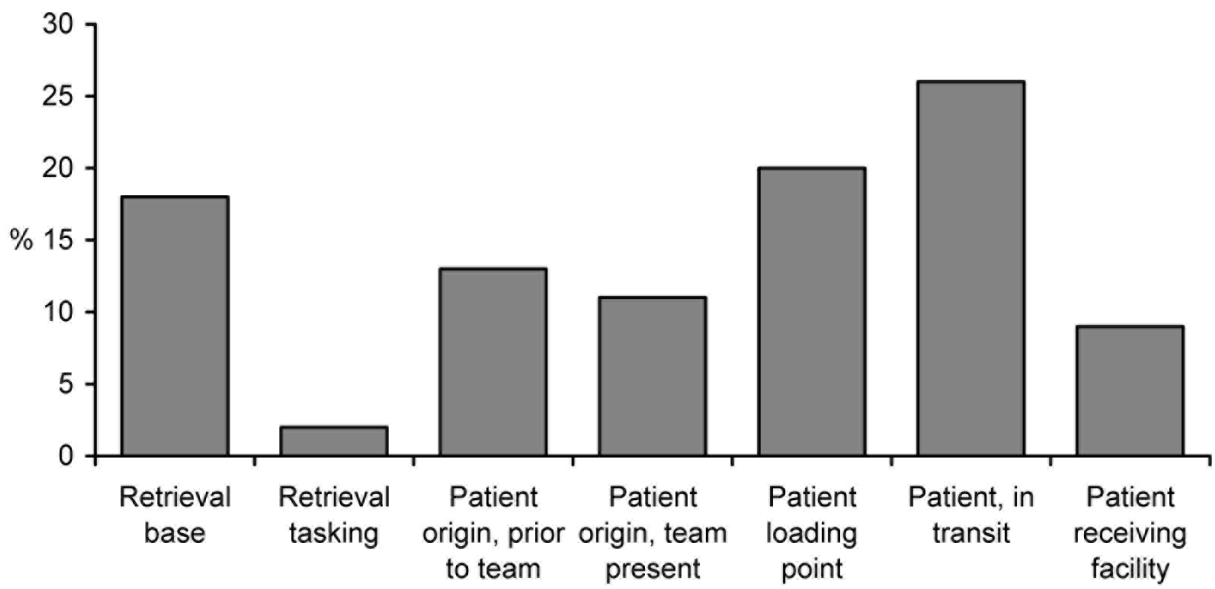

FIGURE 2: Frequency of incident occurrence by stage of retrieval.

TABLE 6
System based contributing factors

System based contributing factors	Total of all contributing factors	%
Equipment/Monitors/Support services (19.7%)		
• Equipment malfunction	32	8.9
• No equipment/monitor	20	5.5
• No other support services	9	2.5
• No bed/facility	8	2.2
• Malfunction of other support services	2	0.6
Team Cognitive factors (11.3%)		
• Communication problem	16	4.4
• Poor team work	13	3.6
• Inappropriate action	9	2.5
• Lack of supervision	3	0.8
Management/Corporate culture (9.6%)		
• Pressure to proceed	19	5.2
• Poor management decision	16	4.4
Protocols/Policies (6.9%)		
• Failure to provide/enforce policy/protocol	13	3.6
• Lack of policy/protocol	12	3.3
Staff (5%)		
• Insufficient training	7	1.9
• Staff new/unfamiliar	6	1.7
• Insufficient staff	5	1.4
Supplies/Labelling (1.2%)		
• Unsuitable supplies	2	0.6
• Lack of supplies	1	0.3
• Poor labelling	1	0.3

TABLE 7
Human based contributing factors

Human based contributing factors	Total	% of all contributing factors
Violation/Rule based (18.8%)		
* Failure to check equipment	21	5.8
* Failure to follow policy/protocol	14	3.9
* Took a short cut	9	2.5
* Failure to apply basic patient care	8	2.2
* Failure to act on available information	8	2.2
* Took a risk	7	1.9
* Failure to attend as required	1	0.3
Skill based (15%)		
* Haste	27	7.5
* Distraction	9	2.5
* Inattention	9	2.5
* Fatigue	8	2.2
* Stress	1	0.3
Knowledge based (9.1%)		
* Unfamiliarity equipment/environment	11	3
* Inadequate/wrong knowledge	10	2.8
* Inexperience/inadequate training	5	1.4
* Technical problem with procedure	4	1.1
* Error of diagnosis	3	0.8

and on occasions when more than one incident was documented ($P<0.0001$).

DISCUSSION

Incidents identified during retrievals were mostly problems with equipment or patient care. Nearly half occurred during patient loading or whilst the patient was in transit to the receiving facility, and 26% occurred at the site of patient origin. Almost 60% of forms documented associated harm and 91% documented the incidents as preventable. Human factors were reported in 42% and system factors in 54%, findings consistent with anaesthesia and other socio technical endeavours[35].

Problems related to equipment contributed to 36% of all incidents, similar to the 30%[36] and 39%[13] of reports for anaesthesia-related equipment problems. Power failure due to exhaustion of internal batteries was the most common problem. Alternative power sources, and the means to connect to them, should be a key requirement for retrieval operations. These may be on board AC or DC power supplies or the carriage of spare batteries. The latter is the least efficient alternative as they add extra weight and bulk, and not all medical equipment uses replaceable batteries or batteries of the same type. Retrieval services have developed innovative strategies, such as stretcher bridges[37], that attempt to address some of these equipment problems.

Example 1

While loading into ambulance, arterial line pressure bag fell off patient and became disconnected, with 1 litre of saline under pressure squirted all over cabin. Also during this time, BP noted to be rising steeply. Only when went to hand bag patient, noted that $ETCO_2$ was 52 mmHg (especially in patient with an intracranial haemorrhage). $ETCO_2$ monitor had actually detected this, but since turned on had been constantly alarming low battery state and audible alarms had been disabled! Problems then all corrected, with return of BP but impact on patient outcome uncertain.

Retrieval equipment problems sometimes arose because the equipment was sourced from other services (e.g., oxygen supplies/fittings and patient loading devices from receiving sites). In contrast, there were no reports of on-board oxygen or loading equipment problems. This suggests that self-reliance for equipment by retrieval services should be encouraged. This should be accompanied by strategies that address the not infrequent problem of missing equipment due to failure to check or inadequate preparation at the retrieval base. Haste, failure to check and pressure to proceed were common contributing factors. Failure to check was documented in 14% of anaesthesia-related incident reports[36]; equipment checks prior to commencement of an

anaesthetic are now mandatory. Retrieval services should also have mandatory checking procedures.

Examples of equipment problems

1. *Arterial transducer missing.*
2. *Wrights (sic) spirometer malfunction.*
3. *Oxylog 2000 (sic) reading flow inoperable. No transformer to recharge.*
4. *Syringe pumps batteries run out mid-flight due to length of time at retrieval site.*
5. *Propaq (sic), batteries ran out on arrival at receiving hospital.*

Medical equipment used for retrieval is designed primarily for in-hospital use and not for the more hazardous out-of-hospital environment. This study highlighted the particular occurrence of breathing circuit, airway and vascular access problems. Equipment designs more suited to the transport environment should incorporate design features to prevent some of these problems. Failing that, there should be provision of a means for their early detection. The latter would require the use of reliable patient monitors with features such as better artefact rejection, appropriate visual[38] and audible displays, suitable alarm functions, power consumption and size. Within aviation, emphasis is given to 'cockpit' design and ergonomics. Similar consideration should be given to medical equipment design and placement in relation to the ergonomics of the 'clinical cockpit' section of the transport vehicle. Further work is needed in this area.

Problems affecting patient care made up 26% of incidents. They related mostly to clinical management at the site of patient origin and reception at the patient-receiving facility. The importance of early resuscitation for critically ill patients[39,40], stabilization prior to transport and appropriate escorts have been well documented[28,29] and incorporated into guidelines for patient transportation[41-43]. Retrieval teams have the capacity to deliver critical care skills where they may otherwise not be available. Their capacity to do so may be limited by transport operational issues, for example the size of retrieval team and the quantity of medical equipment that can be transported. In these situations early referral, accurate information and planning and preparation at the retrieval base are crucial. This study identified that the problem of the patient's condition being more severe than expected was common, and associated with inadequate referral information and treatment at the site of patient origin. Such problems can be at least partially addressed at a local level by access to regional transfer guidelines[44], and the use of information pro formae at time of referral.

Retrieval teams face many challenges when caring for the critically ill, especially in remote locations and when confined to the retrieval vehicle. Difficulties with clinical procedures, equipment problems, problems with the airway (including missed oesophageal intubation) drug errors and loading difficulties were some of the problems documented. These underscore the importance of retrieval team training and the use of checklist and crises management algorithms, and having the necessary equipment (such as capnography). Some of the recently published crisis management algorithms for anaesthesia could be adapted for use in retrieval and during crew resource management training by retrieval teams.

Problems at the patient reception facility were equipment problems, lack of preparedness to receive the patient, and not being forewarned of the patient's condition. The means for good communication between retrieval and receiving staff prior to patient arrival, and its appropriate use, are important but frequently overlooked. Appropriate equipment and staff should be present when the patient arrives.

Example 2

Patient on GTN infusion and atenolol infusion to keep mean arterial pressure less than 100 mmHg. At receiving hospital all monitoring removed and no adequate bed space and preparation of monitoring. At receiving hospital, asked to give handover 4 times (3× to medical staff and 1× to nursing staff).

There is debate in the literature in relation to the impact of vehicle selection upon patient and system outcomes[45-48]. Transport operational problems were documented for 10% of incidents, with certain incidents being associated with particular types of vehicles, such as adverse weather with helicopter operations, loading difficulties with fixed wing aircraft and vehicle configuration with road vehicles. Vehicle selection was not associated with preventability or severity of incidents. Transport operational problems documented in this study may have been unique to the local environment, and may not necessarily be applicable to other services.

Example 3

1. *No keys to open shed where mechanical lifter stored. Patient taken onboard by carrying stretcher and lifting manually in 2 stages.*
2. *Attempted inter hospital transfer. Poor weather conditions meant helicopter transfer aborted but prolonged road transfer instead.*

Factors minimizing retrieval incident outcomes were good crew skills and teamwork (42%) and re-

evaluation of the patient or equipment. Patient monitoring was a factor in only 15%, and is in contrast to anaesthetic practice where an equal proportion of incidents are first detected by humans and by monitors[49]. This may reflect a lesser reliance by retrieval staff on monitors because of their reduced reliability in association with critically ill patients[50], the impact of the transport environment[51,38] and concerns about artifacts and overall frequency of equipment problems during retrieval. These observations further highlight the need for retrieval-specific equipment design. They support the use of more invasive and reliable means of monitoring during retrieval, such as invasive arterial pressure monitoring. These observations are consistent with intensive care incident reports[10] supporting the concept of retrieval, being akin to an 'ICU in the sky'.

Retrieval incidents were complex as they often involved more than one contributing factor (70%) and retrieval stage (20%). Minimizing factors were mostly complex solutions involving crew skills and teamwork, repeated evaluations of equipment and patients and good interpersonal communication. Mitigation of adverse events through productive interaction amongst team members and development of novel solutions to such problems has been suggested[52] and emphasizes the importance of anticipation of, recognition of, training for, and recovery from adverse events[53]. The value of retrieval crew non-technical skills[54], and crew resource management training, ideally using simulation, is now well recognized. Although there are retrieval services that are known to utilize procedures for incident prevention and/or harm mitigation, this study did not explore their impact upon actual incidents and is an area of future research.

Retrievals are associated with factors known to degrade human performance such as fatigue, noise, vibration and uncomfortable ambient temperatures[55-57]. Furthermore, the consequences of retrieval incidents documented in this study—actual patient or crew harm in 59%—can potentially generate further stress[58] and degradation of retrieval staff performance. Life stressors are more prevalent in individuals who have been identified as having contributed to aviation accidents[59]. The extent and the means by which these problems affect retrieval team performance requires further consideration, as do methods used to select retrieval staff.

This study was limited to voluntary incident reporting by retrieval team members and therefore would not have captured all the problems associated with retrieval. A comparison of incident reports with medicolegal reports revealed that certain problems such as corneal abrasions, nerve damage and musculoskeletal problems, which only manifest later, are grossly under-reported by an incident reporting process[60]. Reporting may have also been biased towards unusual or particularly dangerous incidents or those with particular significance to the reporter[16,58].

Incidents that occur during retrieval may also occur during intra-hospital transport, anaesthesia, in the Intensive Care Unit and in the Emergency Department. Lessons learnt in these areas should also be applied to retrieval, and potentially avoid patient harm. For example, deaths as a result of undetected oesophageal intubation have virtually been eliminated from anaesthesia in Australia[60], having been a major cause of morbidity and mortality world wide prior to 1990[61]. Similarly, a case of a blocked filter resulting in serious compromise of patient ventilation, and which was used to introduce a series of papers on crises management[62], is as relevant to retrieval medicine as it is to the practice of anaesthesia. Once documented, such problems lend to upgrading crisis management algorithms. There are clear benefits in having a central national repository of problems from all branches of medicine, so that lessons learnt in one discipline can be applied to others. Ideally incidents, including those from retrieval, should be elicited, classified, stored, and analysed in a fashion similar to all other areas of medicine.

In summary this study identified and characterized incidents that occurred during retrieval, and offered insights into potential means of preventing or more reliably detecting similar incidents in the future. Such information can help to better understand the complexity of factors associated with retrieval and focus strategic interventions that prevent or minimize the consequences of retrieval incidents upon staff and patients. Future research strategies should be aimed towards increasing the scope and depth of information about things that go wrong during retrieval, towards better understanding their impact and developing and implementing strategies to address them.

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