Keeping Patients Safe During Intrahospital Transport

Darcy Day, RN, BSN, CCRN, CEN

Protecting critically ill patients from harm by constant monitoring and prompt intervention is a primary responsibility of nurses in the intensive care unit (ICU). This concept goes back to Florence Nightingale, credited as the first to use an “ICU” by placing the sickest patients nearest the nursing station for closer monitoring.1 Today, the ICU is considered the safest place with the highest level of monitoring for critically ill patients.3,4 But what about when the patient leaves the ICU for diagnostic or therapeutic procedures? Transport of ICU patients out of the ICU for tests and procedures is a necessary part of critical care,5 but there is “considerable danger for the patient to leave the ICU.”6

Transporting patients causes stress for many ICU nurses as they perceive the patient to be more vulnerable, while at the same time the resources available to the patient may be more limited.7 The standard for intrahospital transport is to provide the same level of care, monitoring, and intervention as are available in the ICU.8,9 The goal of this article is to provide a workable, organized framework for safe intrahospital transport of critical care patients. The target audience is ICU nurses who are required to transport their patients for test and procedures.

Studies of Intrahospital Transport

The literature search for the topic of intrahospital transport of critically ill patients consisted of multiple medical databases, article bibliographies, and suggested “related articles.” In addition, the Web sites for various patient safety organizations were checked for transport data and guidelines. National and international critical care professional organizations were also consulted. Research published on out-of-ICU patient transport since the 1980s indicates an overall adverse event rate of up to 70%.2,15-17 Most of these data are not recent, with most studies published before 2006. Studies on intrahospital transport written in English, published from 1999 to June 2009, and used in this article are summarized in Table 1.

PRIME POINTS

- The standard for intrahospital transport is to provide the same level of care, monitoring, and intervention that are available in the ICU.

- The sicker the patient, the greater the chance of problems during transport.

- Safety considerations to anticipate before transport include specific patient considerations, potential handoffs, equipment, timing, route, and destination.

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**Systems-Based Mishaps**

Mishaps (Table 2) during transport are categorized as systems based or patient based.2,15,17,18 Systems-based mishaps may be further subdivided into 2 groups, equipment based and human based, both often resulting from poor preplanning.2,15,17,18 Examples of equipment-based mishaps include battery failure of portable equipment, monitor malfunction, and depletion of portable oxygen supplies.16,17,20 The reported prevalence of equipment-related mishaps during critical care transport is from 11% to 34%.2,13,16-18,21

Human-based mishaps develop from inadequate training, monitoring, and communication.5,17,18 Inadequate communication may cause a delay in procedures, potentially compromising safety and resuscitation of patients.7,9,10,14,18 Suboptimal monitoring and agitation of the patient may result in unplanned extubation.5,17,20 Inexperience may result in the disconnection or withdrawal of intravenous catheters, a mishap potentially resulting in disruption of therapy, embolus, and/or blood loss, all potentially leading to instability in the patient’s condition.2,17,21,20

**Patient-Based Mishaps**

Patient-based mishaps refer to physiological deterioration related to critical illness; the sicker the patient, the greater the chance of problems during transport.17,21 Based on the patient’s acuity, these problems could have happened as readily in the ICU as during transport.20,21 Sicker patients require more frequent transport for diagnostics/procedures, especially during the first 24 hours after admission to the ICU.21 Lahner et al1 reported that urgent rather than elective transport may significantly increase the risk of mishaps. In that study, “critical incidents” occurred in 7.8% of emergent transports versus 2.4% of elective transports (P < .05). In a retrospective study of 948 patients with 413 transported 1 or more times, Voigt et al20 noted the transported patients had longer stays in the ICU and hospital and increased mortality, lending support to the hypothesis that patients requiring transport tend to be sicker. No mishaps or adverse events were described. No direct link between intrahospital transport and mortality were noted in this study, consistent with studies by Lahner et al,6 Papson et al,21 and Mazza et al (Table 1).

**Adverse Events From Mishaps**

Few recent publications describe adverse events caused by mishaps during intrahospital transport. Most data are more than 10 years old. Adverse events described in studies from 2005 forward include decreases in level of consciousness requiring intubation,21 decreases in oxygenation,17 ventilator-associated pneumonia (VAP),20 changes in ventilation resulting in hyperventilation or hypoponnia,5,17 changes in vital signs including severe hypotension/change in blood pressure exceeding 20%,16,17,21 hypothermia,16 increased intracranial pressure (ICP),20 and agitation requiring intervention.1 As far as cardiac arrest during transport, Papson et al21 reported 3 cardiac arrests, and Gillman et al16 reported 1 episode of ventricular fibrillation and 1 episode of asystole. Despite these adverse events, neither group reported any deaths related to transport. A list of adverse events resulting from intrahospital transport is presented in Table 3.

**Guidelines for Intrahospital Transport**

Several professional organizations, including the Society of Critical Care Medicine (SCCM), the American Association of Respiratory Care, the European Society of Intensive Care Medicine (ESICM), the Study Group for Safety in Anesthesia and Intensive Care (SIAARTI), and the Australasian College for Emergency Medicine, have published guidelines for intrahospital transport. These limited guidelines come mainly from small single-center studies, often observational or retrospective. Frequently, the guidelines are anecdotal, based on expert opinion or experience.23 All of the published guidelines from the preceding professional organizations except for the SIAARTI, are 5 or more years old. The Web sites of each group were checked for more current information, but no updates were found. According to the guidelines, each hospital should have a written protocol for intrahospital trans-
A protocol has been developed by a multidisciplinary team and evaluated by a quality improvement process. This protocol should address pretransport communication and coordination, equipment, monitoring, and patient care during transport.

**Table 1** Summary of studies on intrahospital transport published between 1999 and 2009

<table>
<thead>
<tr>
<th>Reference, design, patients</th>
<th>What studied, measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waydhas, 1999 MEDLINE search</td>
<td>Factors examined:</td>
</tr>
<tr>
<td>Most patients trauma/surgical with some medical, pediatric, or neurological</td>
<td>1. Adverse events: cardiac, respiratory, equipment</td>
</tr>
<tr>
<td></td>
<td>2. Patient-related factors</td>
</tr>
<tr>
<td></td>
<td>3. Risk/benefit evaluation</td>
</tr>
<tr>
<td>Lovell et al, 2001 Audit of 97 intrahospital transports of critically ill patients</td>
<td>Goal of audit to assess factors leading to problems during transport; transport staff provided information on patient, treatment, difficulties</td>
</tr>
<tr>
<td>Beckmann et al, 2004 Cross-sectional review Patients from 176 reports submitted to Australian Incident Monitoring in Intensive Care</td>
<td>176 submitted reports describing 191 incidents during intrahospital transports</td>
</tr>
<tr>
<td>Scheck et al, 2004 Prospective, observational 30 critical trauma patients</td>
<td>Active vs passive warming in normothermic transported trauma patients randomized to active warming with heating blanket at 42.0°C vs passive warming with heating blanket turned off</td>
</tr>
<tr>
<td>Bercault et al, 2005 Exposed/unexposed matched cohort of 523 patients receiving mechanical ventilation: 118 of 228 transported patients matched with 118 of 295 patients not transported</td>
<td>VAP occurrence in transported patients matched to that in patients not transported for 6 criteria: indication for and duration of mechanical ventilation, duration of administration of antibiotic, age, surgical procedures, and probability of death</td>
</tr>
<tr>
<td>Gillman et al, 2006 Prospective, observational, and retrospective chart audit 290 patients admitted from ED to ICU</td>
<td>Type and number of adverse events and percentage of delayed transfers measured; delayed transfer defined as &gt;20 min from time patient was identified as ready for transfer and ICU was notified to time of departure from ED</td>
</tr>
<tr>
<td>Lahner et al, 2007 Prospective, observational 226 ICU patients undergoing 452 transports</td>
<td>Occurrence of transport-related complications</td>
</tr>
<tr>
<td>Papson et al, 2007 Prospective, observational 297 critically ill ED patients making 339 transports</td>
<td>Unexpected events during transport, whether intervention required, adverse outcome Experienced vs less experienced transporters compared (attending vs resident physicians)</td>
</tr>
<tr>
<td>Mazza et al, 2008 Prospective, cohort with before/after evaluation 26 patients receiving mechanical ventilation, 37 transports; physician, nurse, respiratory therapist on all transports</td>
<td>Oximetry, cardiac monitoring, blood pressure measured immediately before change to transport ventilator and immediately after return to bedside ventilator; any complication during transport or agitation of patient also recorded</td>
</tr>
<tr>
<td>Voigt et al, 2009 Retrospective review 948 patients from medical-surgical ICU at a cancer referral hospital</td>
<td>Clinical characteristics and outcomes of patients with and without transport; transport timing patterns also studied</td>
</tr>
<tr>
<td>Zuchelo and Chiavone, 2009 Prospective, observational, nonrandomized 2 hospitals, 48 patients receiving mechanical ventilation, 58 transports</td>
<td>Objective: identify cardiorespiratory alterations and adverse events occurring during transport; before/after evaluation of P/F ratio, ABG, vital signs, GCS score, Ramsey sedation score, mechanical ventilation parameters, infused medications</td>
</tr>
</tbody>
</table>

Abbreviations: ABG, arterial blood gas analysis; ED, emergency department; GCS, Glasgow Coma Scale; ICU, intensive care unit; ISS, Injury Severity Score; P/F ratio, PaO2/FIO2, partial pressure of oxygen/fraction of inspired oxygen; PEEP, positive end-expiratory pressure; TISS, Therapeutic Intervention Scoring System; VAP, ventilator-associated pneumonia.
Results, conclusions

Adverse events occur in up to 70% of transports. Patient-related factors: mechanical ventilation, PEEP, high ISS, high TISS. Good risk/benefit ratio: change in patient management 40%-50%. Authors’ conclusion: guidelines must be followed to avoid adverse events during transport.

62% of transports reported a complication; 45% of these complications related to equipment or transport environment; 31% related to patient, 15% related to both patient and equipment or environment.

Authors’ conclusion: many problems are preventable with better pretransport planning and communication.

61% of incidents related to staff management issues including poor communication and inadequate monitoring; 39% of incidents due to equipment problems; 31% of incidents resulted in major physiological derangement.

Authors’ conclusion: intrahospital transport is significantly risky for patients; protocols are necessary for staff, equipment, monitoring.

Both groups’ pretransport temperature 36.4°C (SD, 0.1°C). Temperature in passive warming group decreased to 34.7°C (SD, 0.6°C).

Authors’ conclusion: critical trauma patients should be actively warmed during transport.

VAP rates in transported patients, 26% vs VAP rate in nontransported patients, 10%.

Authors’ conclusion: intrahospital transport is associated with a significant risk for development of VAP.

Adverse events: equipment related, 9%; hypothermia, 7%; respiratory/cardiac changes, 6%.

Transfer delays: 38%; delay >1 h, 14%.

Authors’ conclusion: rates of adverse events lower than rates reported in earlier studies; results should be used for future benchmarking.

Overall rate of critical incidents: 4.2%. No direct association between transport and mortality. Risk factors for adverse events during transport: mechanical ventilation with PEEP, need for catecholamine support. Acute vs elective transport significantly increased adverse events.

Authors’ conclusion: overall, transport complications have decreased, but notable risk remains for sicker patients and for transports of greater urgency.

Unexpected events in 68% of transports. Most common: equipment problems, hypotension, inadequate sedation/paralysis. Intervention required: 79% of unexpected events. No patient died during transport, but 3 had cardiac arrest. Experienced physicians had significantly fewer unexpected events than resident physicians had (130 vs 221).

Authors’ conclusion: experienced transporters have fewer adverse events.

Complications in 32% of transfers with agitation in 66% of these.

Authors’ conclusion: critically ill patients can be safely transported with use of proper equipment and multidisciplinary team. Transport should not be withheld. Transport resulted in change in plan 24% of time in this study.

Transported ICU patients were sicker, had longer ICU/hospital stays, and had increased mortality.

Authors’ conclusion: confirmation of previously described link between transports and illness severity. Authors also note significant number of transports during first 24 h of ICU stay (27% of total).

Common cardiorespiratory alterations (67%) with adverse events (76%).

Authors’ conclusion: these high statistics are due to acuity of patients, poor monitoring, and need for better transport planning.

include transport scenarios during classes for nurses new to critical care. Every opportunity for a “travel experience” during orientation could be used to facilitate familiarity with routes, the destination, the procedures, and the personnel.

The Agency for Healthcare Research and Quality (AHRQ) notes that “intrahospital transport is probably quite risky but has been understudied, so the literature does not include a scientific assessment of best practice.” The AHRQ guidelines emphasize training staff about handoffs, troubleshooting equipment, how to get help, and competency. In addition, the AHRQ supports development of a tool, such as a scoring system for patients’ acuity, for pretransport assessment to evaluate patients’ stability for travel.

Published guidelines on documentation during intrahospital transport are nonspecific but state that documentation should summarize the patient’s clinical status and tolerance of transport. The AHRQ supports the patient’s clinical status and tolerance of transport. Necessary pretransport documentation includes the consent form for the procedure (as applicable), current orders, code status, and any signed emergency protocols per institution.

During transport, monitoring data, such as vital signs, score on the Glasgow Coma Scale, pupil size/reaction, ICP, and score on a pain scale should be noted and recorded.

Patency of all catheters/tubes, maintenance of spine immobilization if required, and an assessment of the procedure site should also be recorded.

Only 1 recommendation was found about the frequency of documenting monitoring data. The Italian group, SIAARTI, advises that monitoring
per institutional policy. Review of these reports may facilitate learning better ways to transport patients safely. A standard quality improvement process should be in place to improve patient safety.14,18

Organizing Safe Transport

The AHRQ provides a list of questions to consider when planning patient transport.24 These questions can be organized by using the 5 Ws (why-who-what-where) as a memory prompt to promote safe transport (Table 4). The rest of this article uses the 5-Ws approach to discuss intrahospital transport in more detail.

Why

The first consideration for intrahospital transport is the potential benefit for the patient versus the potential risks to the patient.27 “Benefit” refers to a diagnostic test that alters management or to a therapeutic procedure that improves outcome.7 “Risk” refers to the potential danger to the patient, directly related to the patient’s level of stability. Red flags to consider when planning transport are noted in Table 5. Benefit must outweigh risk, with the transport in the best interest of the patient.3,6,11-14,31,33 In a review of transport literature published in 1999, Waydhas et al2 reported a change in management in 40% to 50% of patients transported for diagnostic procedures, “indicating a good risk/benefit ratio.” These older data are not supplemented by more recent studies because little recent research has been conducted.

Questions to evaluate transport risk/benefit are provided in Table 6. To evaluate risk/benefit data be recorded at least every 15 minutes. Other necessary documentation: all medications administered, clinical changes, events requiring intervention, and the patient’s response to intervention.31,14,20,27,28,34,35

Mishaps and adverse events may be documented in incident reports.
for transport, questions include the following:

1. Are bedside alternatives available so the patient does not have to leave the ICU? Bedside alternatives range from basic portable chest radiography to the increasingly sophisticated bedside echocardiography and bedside ultrasound. Both echocardiography and ultrasound can be used to determine the cause of unexplained hypotension.38,39 Echocardiography is particularly useful for evaluation of systolic and diastolic cardiac function, valves, thoracic aortic dissection, and intracardiac shunts.38 Ultrasound can be used to evaluate possible abdominal bleeding after trauma, to check for possible aortic aneurysm, and to guide placement of catheters.39

The second question to ask when assessing transport risk/benefit addresses the treatment plan: Is this test crucial to the treatment plan? For example, computed tomography (CT) is pivotal for definitive management of loss of consciousness in trauma patients.7,11,37 If the diagnostic procedure is unlikely to alter management to improve outcome, the transport must be questioned.11,14

The third question relates to procedures requiring patient transport: Does the patient require transport because a lifesaving procedure can be done only outside the ICU? Patients with a pelvic fracture and active bleeding, however unstable, must be taken to the angiography suite for embolization to stop the bleeding.37 In an emergent situation, vital signs including intracranial pressure (ICP) and laboratory results should be normalized as much as possible before transport,23 but should not delay transport.37 In this situation, the resuscitation must be ongoing, and of the same standard as in the ICU.1,7,9,11,13,14 Extra equipment, such as rapid blood infusers, may need to be brought from the ICU to continue resuscitation during

Table 4 Organizing safe transport: transport assessment questions from the Agency for Healthcare Research and Quality

<table>
<thead>
<tr>
<th>Topic</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why</td>
<td>Why is this transport necessary? Evaluating risks of transport vs benefits of transport Will management potentially change? Is the transport critical for outcome? Are bedside alternatives available?</td>
</tr>
<tr>
<td>Who</td>
<td>Who is the patient? Current patient care requirements Who should accompany the patient? Based on acuity Are handoffs required?</td>
</tr>
<tr>
<td>What</td>
<td>What equipment must be brought with the patient? What level of monitoring is required? What ongoing intervention/resuscitation is required? Consider: Needs of the particular patient What is available at the destination? Organize equipment using the ABCs of airway-breathing-circulation</td>
</tr>
<tr>
<td>When</td>
<td>When is the procedure happening? Collaboration for optimal timing of the procedure No waiting at destination Timing of medications/treatments required before procedure</td>
</tr>
<tr>
<td>Where</td>
<td>Where is the best route to the destination for optimal patient safety? Consider: flooring, elevators, proximity of help Does this destination have special safety requirements? Example: magnetic resonance imaging</td>
</tr>
</tbody>
</table>

Table 5 Physiological red flags when considering transport of patients

- High ventilatory requirements reflecting difficulty oxygenating adequately and/or ventilating patient6,12,18 Example: Fraction of inspired oxygen (FIO₂) > 0.6, positive end-expiratory pressure (PEEP) > 10 cm H₂O, plateau pressure > 30 cm H₂O Pressure limiting despite sedation Inverse ratio ventilation, high-frequency oscillatory ventilation Noninvasive ventilation without battery power, dependent on
- More than 2 chest tubes and/or unable to tolerate being off suction12
- Hemodynamically unstable cardiac rhythm despite antiarrhythmic therapy12 Transvenous pacemaker with poor capture Intra-aortic balloon pump, dependent on
- Labile blood pressure requiring frequent fluid boluses or titration of infusions1,12
- Bleeding patient with ongoing resuscitation12,37
- Retractable intracranial pressure requiring frequent intervention12
- Patient with abdominal compartment syndrome (unless going to operating room for decompression laparotomy); open abdomen with exposed viscera12
- Patient requiring continuous renal replacement therapy6
- Unstable cervical spine fracture12
transport. “If the patient does not receive the required critical care en route, the damage occurs and in many cases becomes irreversible.”10

Who

Under “who,” there are 3 considerations: Who is the patient, who will be providing the direct patient care, and will a handoff be required?

Who Is the Patient? The nurse must know the particular patient, his/her current problems, level of stability, relevant history, and reason for the transport. The ICU nurse also needs to know if the patient meets the requirements of the test/procedure such as not having taken anything by mouth, weight limitation, absence of metallic implants, renal function, allergies, and requirements for catheter size and placement. An example of knowing the patient means knowing if the nonintubated patient will tolerate lying flat, if required, for the procedure. Patients with an unsecured airway may be able to manage by sitting at 90º in the closely monitored ICU environment, but supine on the CT table, they can no longer independently maintain the airway. An idea for evaluating tolerance to lying flat that is used at The Queen’s Medical Center is the “flat test.” The patient is laid flat for 5 to 10 minutes to assess tolerance. If the patient is having increased respiratory effort while lying flat, the patient most likely needs ventilatory support to tolerate the procedure safely.

Who Will Be Caring for the Patient? Guidelines in the literature and from professional organizations (SCCM, ESICM, SIAARTI) recommend critical care patients be accompanied by at least 2 escorts during transport.2,5,7,11,14,27 One of these escorts should be a critical care nurse2 with Advanced Cardiac Life Support certification23,40 and experience with emergency situations.23 Ventilator patients require a respiratory therapist.23 Hemodynamically unstable patients require an intensivist2,7,14; SCCM recommends that the intensivist have training in airway management.21 As previously mentioned, these guidelines are not new, dating from 1999 to 2004. No recent updates were found.

Is Handoff Required for Direct Care Responsibility? The advantages of having the same person directly responsible for the ICU patient as the patient is transported through various diagnostic/procedural areas are a decrease in handoffs and potential communication errors at every interface.41 As noted earlier, transport itself may increase the patient’s vulnerability; if handoffs are involved, vulnerability is increased even more so.41,42

Intrahospital transport may involve handing off the patient to staff at the receiving destination, such as the cardiac catheterization laboratory or angiography. Knowing “who” will be responsible for the patient’s care during the procedure is necessary for direct communication during the handoff. Handoffs are a sensitive time for a patient. Greenberg et al,43 in a review of 444 surgical malpractice claims, found 60 cases where a communication breakdown caused harm to a patient. Of these 60 cases, 43% occurred during handoffs and 39% occurred with changes in the patient’s location.43

Because of patient care errors related to handoffs, the Joint Commission made implementation of a standardized approach to handoff communication a national patient safety goal.34,35 During handoffs, the patient’s current condition and current care plan should be reviewed.14 Many types of handoff formats are available, such as SBAR (situation, background, assessment, recommendation), often used with rapid response systems.34,44 Each institution should standardize handoff communication for continuity.34,43 The handoff should be patient centered and focused on the patient’s needs.42

What

“What” addresses the equipment needed to make the “road trip” a safe one (Table 7). With any transport, “packing” is a balancing act of not enough and too much. Minimally

<table>
<thead>
<tr>
<th>Table 6 Transport decisions (Should he stay or should he go?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>**1. Are there **bedside alternatives <strong>for the procedure?</strong></td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>**2. Is the patient’s condition <strong>stable?</strong></td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>**3. For the patient in <strong>unstable condition:</strong></td>
</tr>
<tr>
<td><strong>A. Is transport to a lifesaving intervention?</strong></td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td><strong>B. Is transport to a diagnostic test pivotal to decision for emergent plan?</strong></td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
</tbody>
</table>
the patient must receive care consistent with ICU standards. However, disorganized clutter from an overabundance of equipment, wires, and tubing can contribute to errors that compromise safety. “More” is not “better” if equipment errors increase and the caregiver is distracted from the patient. The goal is to keep the transport as simple as possible without compromising ICU standards of care.

Equipment to consider bringing, divided according to the ABCs of airway, breathing, and circulation, is listed in Table 7. Equipment to bring is influenced by ICU transport protocol, specific requirements of the patient, and the equipment available at the destination. Less equipment needs to be carried if the destination is well stocked, as transport time between destinations is best minimized. Transport destinations receiving ICU patients must minimally have suction, an oxygen source, accessible electrical outlets, monitors of equal caliber to the ICU, and a readily available code cart. Transport protocols should include requirements for routine checks of equipment used during transport and at destination. Other considerations, using the ABCs, are described in the following paragraphs.

### Airway: Nonintubated Patient
An important concern in the transport of nonintubated patients is the capacity for airway protection. "Establishment and maintenance of a patent airway is always the first priority in care." Transport of a nonintubated but critically ill patient may increase the risk of adverse events during transport. Again, an example is the head-injured patient with a sudden decrease in consciousness. Will this patient be able...
to maintain his airway while being transported for emergent head CT? The hallway and CT table are not ideal places for emergent intubation.

Patient safety is optimized by addressing potential problems before leaving the ICU. Recommendations include preventative intubation for transport if maintenance of the airway or worsening of ventilatory function is a concern.

**Airway: Intubated Patient.** For intubated patients, a primary concern is ensuring the continued patency of the endotracheal tube. One of the most dangerous complications during transport is the loss of an established airway. Intubated patients should be adequately sedated and restrained, as required, for transport. Ways to monitor patency of the endotracheal tube include checking the centimeter depth marker at the teeth (should be unchanged) and listening for equal breath sounds on the right and left sides. Reassessment after each transfer from bed to procedure table and back may be helpful to ensure patency. Suctioning to clear the endotracheal tube of secretions before transport and as needed during transport also helps to maintain endotracheal tube patency.

**Airway: Intubated Patient: End-Tidal Carbon Dioxide Monitoring.** Another way to assess endotracheal tube patency is by monitoring end-tidal carbon dioxide (ETCO₂), the maximum partial pressure of CO₂ at the end of exhalation. Qualitative ETCO₂ detectors are the standard of care (class IIA) for checking endotracheal tube placement during intubation. Monitoring of ETCO₂ is recommended for ensuring airway patency during transport. A rapid decrease in ETCO₂ may signal a displaced or obstructed endotracheal tube.

**Breathing: ETCO₂ Monitoring.** The discussion of ETCO₂ monitoring is continued here in the section on breathing. For patients with healthy lungs, ETCO₂ correlates closely with PaCO₂; ETCO₂ measurements vary approximately 2 to 5 mm below PaCO₂. Close correlation between ETCO₂ and PaCO₂ is less for patients with compromised pulmonary status and a ventilation/perfusion mismatch.

The larger the relative proportion of lung with [ventilation/perfusion] mismatch, the lower the recorded ETCO₂ will be, the larger the gradient between PaCO₂ and ETCO₂.

Two recent prospective studies demonstrate a low correlation between ETCO₂ and PaCO₂ in critically ill patients. In a prospective observational study targeting ETCO₂ to 35 to 40 mm as recommended by the Brain Trauma Foundation, Warner et al reported that patients were hypoventilated 80% of the time and concluded that ETCO₂ may be misleading if used to guide ventilation in critically ill trauma patients ($R=0.28$). In the second prospective study, ETCO₂ was compared with PCO₂ using 170 data points obtained during transport of patients. Similar to Warner et al, Hinkelbein et al concluded that for long transports and/or for patients with impaired pulmonary function, ETCO₂ cannot replace arterial blood gas analysis to guide ventilation ($P<.001$). Thus, as discussed previously, ETCO₂ is a useful tool for evaluating endotracheal tube patency, but caution is required when use of ETCO₂ to target ventilation is considered.

**Breathing: VAP.** Another consideration under breathing is VAP related to transport. VAP is the leading cause of death from nosocomial infection, with an estimated
mortality rate between 20% and 70%. VAP occurs in 25% of patients receiving mechanical ventilation. Bercault et al reported that intra-hospital transport is an independent risk factor for VAP. In their study, intra-hospital transport was independently associated with VAP; 26% of transported patients versus 10% of nontransported patients had VAP diagnosed. Preventing VAP is a current critical care priority with specific protocols, including backrest elevation of 30° to 45° to decrease risk of aspiration. ICU patients positioned flat and supine have higher mortality rates than do patients with the backrest elevated. Although the study by Bercault et al is limited because the patients’ position during transport was not recorded, the authors do advise transporting patients in a semi-recumbent position. Besides backrest elevation, gastric emptying before transport is advised to prevent aspiration leading to VAP.

Breathing: Chest Tubes. Few guidelines concerning chest tubes and transport of patients have been published (listed in PubMed, MEDLINE, or CINAHL). One recommendation is never to clamp chest tubes during transport. Portable suction is required for pneumothoraces with large air leaks and also may be considered for chest tubes with large output, bleeding, and patients with high ventilatory requirements. For patients without these problems, chest tube to water seal, off suction for transport, then reconnected to wall suction at destination is usually well tolerated, although this suggestion is based only on experience. When doubt exists as to how well a patient will tolerate being off suction for transport, a brief trial off of suction before leaving the ICU, along with collaboration with the physician, is suggested.

When chest tubes are connected to water seal, the drainage chamber should be kept below chest level to prevent backflow. Regarding multiple chest tubes, the number of suction outlets available at procedure locations is typically limited. An idea for managing multiple chest tubes on suction is to connect suction tubing together with “Y” connectors so that multiple suction chambers can run off of 1 suction outlet. Multiple chest tubes may already be assembled this way in the ICU, but if not, they may be assembled before transport to save time and improve organization at destination.

Circulation: Monitoring. Minimally, monitoring during transport should be the same as the patient receives in the ICU (Table 9). Although transport can be a vulnerable time for a patient, only 1 guideline was found that addressed frequency of monitoring. The SIAARTI advises that vital signs be recorded every 15 minutes during transport. Depending on the acuity of the patient and the complexity of the procedure, it may be prudent to monitor and record vital signs more frequently.

Monitoring the patient’s temperature during transport can be important. Gillman et al identified a decrease in body temperature in 18% of transported patients studied, with 7% becoming hypothermic (body temperature <35.0°C). Patients may need active warming during transport to prevent hypothermia. In a study by Scheck et al, transported trauma patients warmed with a heating blanket maintained normothermia, whereas the patients who were not actively warmed became hypothermic.

Circulation: Intravenous Catheters. Intravenous catheters must be checked for patency, labeled, and organized before transport. Minimally the patient needs 2 intravenous access sites with the second site available as backup if the first site infiltrates. The “keep it simple” concept can be important for safety. In a study of patients transported from the emergency department, Papson et al reported that 26% of mishaps were related to

Table 8 DOPE: Assessment of sudden respiratory deterioration in intubated patients

<table>
<thead>
<tr>
<th>Topic</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>D: Displacement</td>
<td>Is the endotracheal tube still patent by position? Check breath sounds, chest rise, tube marking at teeth</td>
</tr>
<tr>
<td>O: Obstruction</td>
<td>Mucous plug? Kinks? Check peak pressures, suction patient, drain tubing</td>
</tr>
<tr>
<td>P: Pneumothorax</td>
<td>Check breath sounds, chest rise, peak pressures Chest radiograph only if hemodynamically stable If unstable, needle thoracentesis</td>
</tr>
<tr>
<td>E: Equipment</td>
<td>Is something disconnected? Organized check of entire system</td>
</tr>
</tbody>
</table>

* Based on data from the American Academy of Pediatrics.
intravenous catheters and tubing. Disorganized, tangled tubing leads to confusion, frustration, and a potential increase in errors. Infusions that are not necessary to support vital signs should not be given during transport.27 Intravenous tubing may need to be lengthened27 with extensions to provide enough slack for mobile procedure tables. Intravenous pumps on individual poles (as opposed to pumps attached to the bed) allow the bed to be moved away from the study area, creating an easier, less cluttered path to the patient in an emergency. Identification of a designated intravenous access site, in case of cardiac arrest, for every transport may also help increase organization in an emergency.

Disability (Neurological).

Patients requiring neuroscience multimodality monitoring often travel out of the ICU for diagnostic tests such as CT, perfusion studies, or angiography. These patients minimally must have ICP monitoring while being transported to assess tolerance to procedures and position changes.8,9,23,26,37 Backrest elevation during transport may help maintain ICP control, as is done in the ICU.57-59 Few published guidelines address best practice with neuroscience devices such as ventriculostomies during transport. Common practice in the ICU is to clamp ventriculostomy drains while repositioning patients and while changing backrest elevation to avoid either excessive or diminished drainage.54,59 One hospital advises clamping the ventriculostomy for transport36 because position changes can be frequent during transport and procedures. If the patient does not tolerate clamping the ventriculostomy, as evidenced by an increase in ICP, the ventriculostomy should be leveled at ordered height per institutional policy and unclamped to drain.36

The final topic to consider in this section is transport of patients with spinal cord injuries before definitive care. Patients with injuries of the cervical spine should be immobilized in a cervical collar for transport.36,23,27,37 All patients with spinal cord injuries must be logrolled without bending when they are being positioned and moved to procedural tables with a transfer board and manual cervical immobilization.14,23,27,37 A brief sensorimotor examination after each surface transfer helps verify safe transfer. No published guidelines for transfer between surfaces of patients in cervical traction were found, but

### Table 9 Monitoring during transport

<table>
<thead>
<tr>
<th>Guidelines</th>
<th>Mandatory</th>
<th>Recommended</th>
<th>Ideal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Continuous:</td>
<td>Continuous:</td>
<td>Continuous:</td>
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<tr>
<td></td>
<td>Oxygen saturation</td>
<td>End-tidal carbon dioxide monitoring if patient is intubated</td>
<td>Arterial blood pressure monitoring</td>
</tr>
<tr>
<td></td>
<td>Cardiac monitoring</td>
<td>Heart rate</td>
<td>Intracranial pressure monitoring</td>
</tr>
<tr>
<td></td>
<td>Pulmonary artery waveform if pulmonary artery catheter present</td>
<td>Blood pressure</td>
<td>Breath sounds</td>
</tr>
<tr>
<td></td>
<td>Continuously monitor pulmonary artery waveform to avoid complications: Migration to right ventricle causing cardiac irritability</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Migration to continuous wedge position causing vessel injury</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inter: Respiratory rate</td>
<td>Body temperature (or monitor continuously with temperature probe)</td>
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</tbody>
</table>

*Based on data from Waydhas,5 Braxton et al,8 Warren et al,14 Stevenson et al,23 Beninati et al,26 Torri,27 Peuss and Wiegand,37 Australasian College for Emergency Medicine, Australian and New Zealand College of Anaesthetists and Joint Faculty of Intensive Care Medicine,26 Nagappan,28 Nagler and Krauss,32 Hinkelbein et al,58 and Warner et al.60*
institutional policy and experience suggest that the neurological or orthopedic surgeon should manually maintain cervical traction in these patients during the move. If the patient with an unsecured spinal cord injury is agitated and restless, sedation should be given for safety but only after it has been ensured that the airway is secure.37

**When**

Proper timing contributes to a smooth, safe transport. Pretransport preparation is required for many tests and procedures, and this preparation must be coordinated to the timing of the test. Examples include (1) fasting and withholding anticoagulants for a prescribed period before invasive procedures60 and (2) renal protective protocols consisting of bicarbonate infusions and antioxidants for intravenous administration of contrast material in patients with borderline kidney function.61

Timing also includes collaborating with other health care providers, such as the staff performing the procedure, and respiratory therapy for intubated patients.11,23,27 Organization and collaboration are especially important in transport for emergent procedures that must be performed suddenly. The procedural room, equipment, and staff should be ready when the patient arrives.11,23,27 No critically ill patient should have to wait in a hallway or holding area.23

**Where**

Before the patient leaves the ICU, the safest, most efficient route to the procedural area should be identified.31,33 Consideration ahead of time of flooring, inclines, and sharp narrow turns can be helpful. Elevators should be the largest available and must be “secured”31,33 if necessary, especially with patients in unstable condition, when time is of the essence. Another consideration in choosing the best route is the proximity of emergency help along the way. Recommendations include the availability of a code cart within 4 minutes at any point on the route.31,33 Transporting past the emergency department, operating room, or near other ICUs on the way to procedures increases the likelihood that skilled assistance will be immediately available if an emergency develops en route.

The magnetic field of the equipment used for magnetic resonance imaging reacts to the detection of metal in 5 dangerous ways: projectile objects, twisting displacement of implants, burning, monitoring artifacts, and device malfunction.62,63 Medical devices currently contraindicated for magnetic resonance imaging include pulmonary artery catheters, implantable cardioverter defibrillators, pacemakers, ventricular assist devices, and intraaortic balloon pumps.63 Technology is constantly changing with respect to medical devices and safety of magnetic resonance imaging. Multiple Web sites are available for the latest updates and are recommended.63 The Web site MRI Safety (http://www.mrisafety.com/) contains information on more than 1200 implants and devices. Also, the Institute for Magnetic Resonance Safety, Education, and Research, a multidisciplinary professional organization, has a Web site that includes 2 useful sections: MRI Safety Guidelines and MRI Safety Papers.64 Most mishaps and adverse events in magnetic resonance imaging result from poor screening.63 Each hospital with magnetic resonance imaging capability should have a standardized prescreening form and protocols addressing safety immediately preceding and during the study.63

**Summary**

This article offers recommendations for safe clinical practice during intrahospital transport. Intrahospital transport is potentially dangerous, as demonstrated by multiple single-center studies, and new multicenter studies need to be done. The limited number of studies minimizes the support for clinical decisions; however, reasonable actions are available to consider despite the lack of research evidence. In this article, the available research on intrahospital transport is first reviewed and then an organized approach to optimize patients’ safety during transport, using the prompts why, who, what, when, and where, is presented. “The fortunate outcome of no deterioration during transport has been attributed to preparation and resuscitation.”23

Goals of transport include

1. Continuing management or resuscitation with the same standard of care and monitoring as in the ICU.
3. Achieving a quality study and/or an effective intervention. The information presented in this article should help ICU nurses minimize the risks of transport. 

Financial Disclosures
None reported.

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37. American College of Surgeons Committee on Trauma. Advanced Trauma Life Support. 8th ed. Chicago, IL: American College of Surgeons; 2008;222-223, 144-147, 158, 159-171.


Keeping Patients Safe During Intrahospital Transport
Darcy Day

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