Patient Transportation Part II: Conducting

Interfacility and Intrahospital

Patient Transportation

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Patient Transportation Part II: Conducting Interfacility and Intrahospital Patient Transportation

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Intended Learning Outcomes

Patient Transportation Part II: Conducting Interfacility and Intrahospital Patient Transportation

1. Understand specific safety considerations during interfacility (IFT) and intrahospital (IHT) transport
2. Compare the different advantages and limitations of different modes of patient transportation (fixed wing, rotor wing, and ground)
3. Explain physiologic changes expected during air transportation
4. List effective elements of patient hand-off
5. Review key elements of effective communication before, during, and after transportation
6. Effectively plan the transfer of a critically ill patient using a team approach
7. Conduct patient transfer and deliver needed interventions
8. Identifying problems during patient and troubleshooting
9. Discuss appropriate pre-hospital care based on an assessment of the patient’s condition

eModule Information

Relevant Competencies from CoBaTrICE

Patient Transportation Part II: Conducting Interfacility and Intrahospital Patient Transportation

- **10.1** Undertakes transport of the critically ill patient outside the ICU (intra-hospital as well as inter-hospital)
- **12.2** Communicates effectively with members of the health care team
- **12.3** Maintains accurate and legible records/documentation

1. Introduction

Patient Transportation Part I provided an introduction and overview to the world of patient transportation. Part II will review how to effectively prepare for and execute patient transfer. It will cover clinical and logistic aspects of interfacility (IFT) and intrahospital (IHT) transport.

2. Conducting Interfacility Patient Transport

Moving critically ill patients is paramount to getting patients the specific care and interventions they need. Part I: Introduction to Patient Transport reviewed general information and foundational principles of patient transport. Part II: Conducting Patient Transport focuses on the logistics, operations, and training of different forms of patient transport. The primary goal of this module is to give clinicians insight into important nuts and bolts of moving a critically ill patient.

2. 1. General Safety Considerations

Safety is of utmost importance. Some incidents can be avoided by proper preparation. Every team member must be trained in working with all patient transport equipment. The equipment should be checked before and after each transfer. Regular checks by members of other departments do not preclude an additional check by the intrahospital transport (IHT) team before the patient leaves the ICU to ensure that all equipment is functioning properly. The transfer team is responsible for the equipment as well as for the wellbeing of the patient.

Communication is key between the sending team, the transport team, and the receiving team. Coordination of patient transport and communication of readiness, timing, anticipated complications, and interventions is critical.

Whether the patient movement is IFT or IHT, appropriate protections for the patient and transport team is always a concern. This includes protection from the elements such as warm clothes for the team or specialized insulated blankets for the patients. Likewise, eye protection and ear protection in noisy environments is important. Finally, precautions from transmission of infection are an important consideration; for example, COVID-19 positive patients should wear a surgical mask. COVID-19 patients that are intubated should have appropriate filters in line with the ventilator. The transport team should be wearing appropriate aerosol respiratory protective equipment.

The use of a dedicated checklist just before departure (analogous to a 'time out' in the operating room) supports a systematic safety check of equipment and drugs. An often-cited source of error is a problem with the gas supply. Moreover, sometimes adapters, e.g.: for IBP measurement, often get lost.
Appropriate alarm limits should be set and alarm volumes should be set loud enough to be heard and optical alarms should be easily visualized.

The specific aspects of IFT and IHT safety will be discussed in their respective sections.

Anecdote

A patient suffered from severe hypoxic brain injury during transport from the operating room to the ICU. The ventilator was functioning satisfactorily when checked while connected to the mains electricity. However, when not connected to the mains supply, it required pressure from the oxygen cylinder to function. However, the oxygen cylinders had not been checked and were empty; furthermore, the alarms were ignored during transport.

In Text References

(Kulshrestha and Singh. 2016; Warren et al. 2004; Salt et al. 2018; Fanara et al. ; Wilcox et al. 2022)

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2. 2. Special Clinical Environments during Interfacility Transport

Beside a routine transfer from ICU to ICU there is a growing need for time critical transport (e.g.: for thrombectomy in acute ischemic stroke with large vessel occlusion). In these cases, the destination is not necessarily an ICU, but could also be an angiography suite or operating theater. In order to ensure that this poses no risk to the transfer team and the patient, communication with local staff is of great importance. On transport team arrival, this may include ensuring that there is no active delivery of materiel and that equipment is moved so that the team has clear access to the procedure table. In addition, transport to the OR or certain procedural areas may include communicating with the team and providing sterile overgarments to protect the patient from infection.

2. 3. Choosing the Appropriate Transport Vehicle for Interfacility Transport

For IFT, there is little conclusive scientific data available to support a preference for ground vehicles (ambulance) over helicopters (rotary wing) or aircraft (fixed wing). The choice between ground and different air transport platforms depends on many factors, such as availability, staffing, infrastructure, costs, geography, distance, time, and weather conditions. Thus, the choice of transfer modality is an context-specific one.

In general, air medical transport may be preferable if there are clinically important savings in time to the administration of meaningful interventions. Therefore, if it is a reasonable distance (e.g.: more than 50 miles or 80 km) and the patient is experiencing a life-threatening event that a has a time-sensitive intervention with a clear outcome benefit (such as STEMI or major trauma) air medical transport (via rotor wing aircraft) would be reasonable. Alternatively, if distance is far (e.g.: more than 150 miles or 240 km), the patient is stable, and there is a need for space due to extensive equipment, a fixed wing aircraft may be a better option.

It is important consider the total time from getting the patient from bed to bed and not just the time of travel for air medical transport. Getting to and from an aircraft can often take additional time. For example, a fixed wing flight may take 45 minutes from airport to airport, but there are ground legs on either end of the fixed wing transport that take additional time. So, if the time from the sending facility to the airport in traffic is 20 minutes and the time from the airport to the receiving facility is 25 minutes, then the total transport time is closer to 90 minutes. This is a significant addition to the transport time beyond the fixed wing leg. It is important to consider this total out of hospital transport time when planning for logistics such as quantities of various mediations, additional blood products, or oxygen supply.

To facilitate the best use of available resources for critical patient transport, developing standardized decision-making frameworks may assist both sending and receiving providers. That said, the management and transfer of critically ill patients can be nuanced and numerous special circumstances may arise. Therefore, part of the standard practice might include a discussion between the sending provider, transport team, and receiving provider for patients that are less straightforward. In some regions of the world, specialized transport coordinators assist with these decisions. These coordinators are often physicians with specialized training and backgrounds in transport/retrieval medicine that can help navigate the nuanced decision-making process in real time with any and all assets immediately available.

You work in a suburban hospital without a cardiac catheterization lab. A 42-year-old male admitted himself to the ED with chest pain. The ECG shows an obvious antero-septal STEMI. The next cardiac catheterization lab is 50 kilometers away, your own hospital has no helipad. You wonder if a transfer with the helicopter would be faster?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

50 kilometers are a distance usually suitable for ground transfer, especially if there is no landing site at the referring or receiving hospital. An intermittent transfer via ground ambulance to the helicopter is time consuming, so one has to balance the time gained from the helicopters velocity over the time lost for reaching the helicopter.

In Text References

(Diaz, Hendey and Bivins. 2005; McVey, Petrie and Tallon. 2010; Fletcher-Sandersjöö, Frenckner and Broman. 2019; Kulshrestha and Singh. 2016; Warren et al. 2004; Wilcox et al. 2022; Hakim et al. 2020; Meuli et al. 2021; Galvagno SM et al. 2012; Bredmose et al. 2020)

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2. 4. Air Medical Transport

2. 4. 1. Indications

The use of air medical transport in Europe, the United States and Australia differs dramatically and is influenced by distances between hospitals, the history and development of medical services, cooperation with the military, geography, and insurance policies.

In general, Blumen, et al. described a 4-step guideline to consider if air medical transport is appropriate. First, evaluate the patient: How severe is their injury or illness? What is the likelihood they may experience serious deterioration? Second, evaluate the medical care required: What medications is the patient on? Are they requiring specialty equipment for life support such as mechanical ventilation or mechanical circulatory support? Third, evaluate the time-sensitivity of transport: Is getting to definitive intervention time critical? Fourth, consider the logistics: What is the weather, distance, traffic, etc.?

Air medical transport is designed and best-suited to clinical situations involving critically ill and complex patients that have a high likelihood of deterioration, where there is a need to minimize time to a definitive intervention that will provide clear benefit to the patient. That said, it is important to reemphasize that many of these decisions are based on very dynamic circumstances like traffic, weather, or resource availability. For example, if transport for a critically injured, intubated trauma patient by a critical care air medical crew will be 30 minutes and transport by a critical care ground crew will be 60 minutes, then it would be prudent to request air transport. However, if the air crew is not available for another 30-40 minutes because they are already on a mission, immediate dispatch of the ground crew may get the patient to definitive care quicker.

What are the presumed advantages and disadvantages of air medical transport compared to transport by ground ambulance?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

Depending on weather, road conditions and distance, helicopters may arrive faster on the scene, and transport to the most appropriate hospital may also be faster. However, the available space is much smaller in a helicopter, it may carry less equipment, and in case of an adverse event with the patient, unlike a ground ambulance, the helicopter cannot just stop by the road to allow the transport team a calm moment to perform an intervention.

2. 4. 2. Choice of Aircraft

The choice between rotary wing aircraft (helicopters) or fixed wing aircraft (airplanes) should be made following a risk and cost versus benefit analysis using criteria like travel distance, landing infrastructure, weather conditions, and clinical emergency. In general, most organization guidelines recommend considering fixed wing transport for longer distances — distances greater than 100-150 miles (160-240 km), as long as airports and appropriate operation support services are available.

In addition, there may be additional benefits to using fixed wing aircraft under certain conditions, such as adverse weather. Fixed wing aircraft can use instruments to fly in inclement weather that some rotor wing aircraft cannot. Furthermore, many fixed wing aircraft can implement deicing measures that rotor wing aircraft cannot. Finally, in general, fixed wing aircraft can lift more weight and carry additional specialized equipment and personnel, which may be a consideration.

Again, the choice of aircraft is nuanced and highly situation dependent. It is wise to discuss the aircraft choice with the transport team or transport coordinating center to review things on a case-by-case basis.

In Text References

(Taylor et al. 2010; Waldmann, Soni and Rhodes 2008; Kulshrestha and Singh. 2016; Warren et al. 2004; Wilcox et al. 2022; Huff, Keeperman and Osborn. 2021; Judge. 2021; Werman, Stuhlmiller and Floccare. 2015; Blumen, Williams and Peeples 2015)

2. 4. 3. Physiologic Stressors in Air Medical Transport

In addition to the potential risks of air transport as previously discussed, it is important to be aware that air medical transport exposes patients to certain physiologic stressors that either do not exist or may be more intense than those experienced during ground transport.

When a supine patient is exposed to the force of sustained acceleration or deceleration in a vehicle or aircraft, blood flow is directed to the feet or the head depending on the patient's orientation. Theoretically, this may cause cerebral hypo- or hyperperfusion (if the force exceeds cerebral autoregulation or autoregulation is impaired) with a risk of deterioration in patients with intracranial pathology. Cardiac preload and afterload may also be influenced by such forces and may cause deterioration in hemodynamically compromised patients. Studies on the deleterious effects of such forces are limited to air force pilots, and the clinical relevance for critically ill patients during medical transport remains to be determined. However, an understanding of the dynamics and physiology leads to awareness of possible consequences. A proper positioning of the patient may lessen the effects of these forces.

With increasing altitude, barometric pressure and temperature decrease and therefore the partial pressure of oxygen drops. Fixed wing air ambulance cabins are usually pressurized to a pressure equivalent to 2000m above sea level. Without supplemental oxygen, this may lead to hypoxia in critically ill patients. Even this moderate altitude may exacerbate decompression sickness under certain circumstances. Rotary wing air ambulances usually do not have a pressurized cabin, and they operate at lower cruising altitudes. Nevertheless, in special circumstances, e.g.: diving accidents, it is advisable to choose a low altitude flight.

Gas contained in a fixed space will expand with increased altitude or decreased pressure, according to Boyle's law ($P \propto 1/V$). In the case of intracranial, intrapleural or intra-abdominal air, this expansion could cause clinical deterioration and therefore air transport could be unsuitable. Braude. et al. reviewed cases of pneumothoraces to determine if routine placement of a chest drain (thoracostomy tube) was required. In their review, only 6% of patients sustained any significant deterioration attributed directly to the pneumothorax. All of these were successfully treated with emergency needle thoracentesis. Thus, while the change in altitude should be considered in the context of the patient's pathology, providers should also consider the time needed to perform procedures like chest drain placement.

Altitude as additional effects on medical devices. For example, air in the endotracheal cuff also expands with changes in altitude. Delorenzo, et al. found that there were significant changes in cuff pressure to above 30cm H_2O in more than 80% of patients during helicopter transport. While it is unclear if this transient increase in pressure caused significant patient harm, it is certainly concerning. Therefore, if there are significant changes in altitude in unpressurized aircraft, the endotracheal cuff pressure should be checked using a cuff manometer and volume should be adjusted.

Noise and vibration are also important considerations. The noise created by aircraft engines is substantial and can exceed safe levels for regular exposure if the crew does not wear appropriate hearing protection. It can also be uncomfortable and disturbing to patients. In addition, noise can interfere with clinical communication and decrease the ability of providers to auscultate lung sounds, hear alarms, or address patient requests. Vibration in aircraft and turbulence from weather can be uncomfortable, exacerbate motion sickness, and cause vomiting. There can be significant effects on equipment as well; for example, significant turbulence can artificially trigger a mechanical ventilator to deliver breaths.

Finally, temperature and humidity can have a marked impact on patients and providers alike. All involved in the transport are exposed to extremes of temperature, occasionally for extended periods of time. While most vehicles have heating and cooling systems, moving between vehicles or between facilities and vehicles exposes patient and transport team members to rain, snow, sleet, wind, and temperature extremes. Furthermore, even when patients and team members are loaded in an aircraft, it can take time for the heating or cooling systems to control the temperature within a comfortable or clinically appropriate range. Patients should be packaged accordingly. In particular, in adverse weather circumstances they should be well-insulated with blankets and be placed in specialized, protective wraps that keep them warm and dry.

In which clinical situations might air medical transport pose an increased risk for a patient?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

Air medical transport, with the increased elevation above sea level and decreased ambient pressure, may cause closed air spaces to increase their size (e.g.: an undrained pneumothorax, ileus/megacolon or intracranial air after open head injury), according to Boyle's law. Patients with decompression sickness following diving-related injuries may also deteriorate due to the use of air transport.

For more information about the transport of patients with severe trauma, see ESICM Flash Conference: Mathieu Raux. Critical Care Refresher Course Trauma. Transportation of severe trauma. Barcelona 2010.

In Text References

(McVey, Petrie and Tallon. 2010; Maissan et al. 2018; Bassi et al. 2010; Delorenzo et al. 2021; Kulshrestha and Singh. 2016; Blumen, Bence and Webb. 2015)

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2. 5. Preparing for Patient Transportation

Once a mode of transportation has been selected and the transport team is on the way to receive the patient, it is important to recognize the importance of this time interval to optimize all conditions for a swift and safe patient handoff. During this time frame a number of things can be done to prepare the patient, obtain additional supplies, organize medical records, and more to minimize the time during transfer of care.

2. 5. 1. Clinical Preparation and Optimization of the Patient

In Patient Transport Part I we discussed clinical stabilization of the patient. This is perhaps best summarized by Wilcox, et al. in their paper “Interfacility Transport of Critically Ill Patients.” In it they present the following model for pre-transport stabilization and optimization.

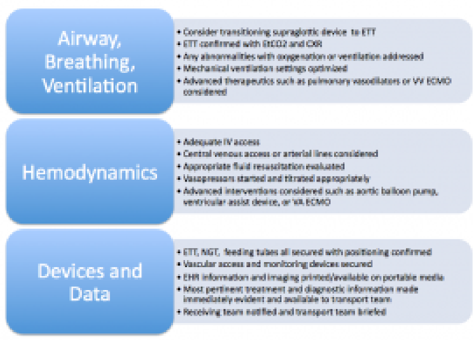

Figure 1: Model for pre-transport stabilization and optimization. Wilcox, et al., 2022

While many of these items are part of general medical management of a critically ill patient, it is worthwhile considering each of these aspects. Any provider, regardless of skill or experience, is liable to overlook aspects of clinical care during periods of high cognitive load: managing critically ill patients, doing critical procedures, talking to consultants, communicating with nurses, etc.

Especially in the setting of emergency department IFT, it is reasonable to review management and decide (in the context of available time) if additional interventions to optimize the parameters are warranted. For example, if a tourniquet is in place, it may be reasonable to deescalate the tourniquet to a pressure dressing knowing there will be a prolonged transport. If a post cardiac arrest patient’s airway was initially managed with an extraglottic device, it may be prudent to weigh the risks and benefits of exchanging the extraglottic device for an endotracheal tube.

Regardless of whether the patient is coming from the ED or the ICU, part of preparation for transport entails anticipating the needs of the patient over the timeframe of the transport. A patient may have a tenuous respiratory status supported with noninvasive positive pressure at moderate to high settings. Although their oxygen saturation and blood gas parameters are acceptable now, does the sending provider anticipate (based on clinical trajectory) that they may deteriorate in the next hour or two before a patient arrives at definitive care? Should an endotracheal tube be placed to facilitate safe transport? Other examples might be: if a patient's hemodynamics are marginal despite initial resuscitation, should an arterial line be placed now so the transport crew can more closely monitor for hemodynamic deterioration in route? Does the patient need additional vascular access for fluids, medications, or blood products?

2. 5. 2. Logistical Considerations

Transfer time can be reduced by considering logistics prior to transport team arrival. Consider aspects of patient care such as medication administration. If a patient is intubated on sedative and analgesic agents, the time frame of the transport, doses of medications needed and infusion rates must be considered. If the patient is requiring medication of which supply might run out in transport, additional medication should be obtained in advance. Better yet, fresh medication should be hung or drawn up into syringes so as to start the transport team with maximal time to run on different drips. This especially applies to medications such as vasoactive drips, inotropes, or antihypertensives. Additional medication should be ordered and ready from the pharmacy for the transport team if they may be needed within the timeframe of the transport.

It is reasonable to also consider acquiring very specific medications that flight teams may not have or only have a limited amount of, such as blood products. Even very capable critical care transport services are limited in the number and variety of blood products they carry. If a critically injured trauma patient or a patient with active gastrointestinal bleeding is requiring multiple blood products for transfusion, it would be prudent to call the blood bank in advance and order additional units to support the patient during transport. As mentioned, transport teams often carry limited blood supply.

Also, considering other emergency therapies may be helpful. That is, if it was necessary to provide push dose vasoactive medications, antidotes, or any other critical therapies during the resuscitation it may be good to prepare and provide these medications to the transport team. The sending provider should consider contacting the transporting agency to see if they have certain medications available on their transport vehicles. If there is a specialty medication the transport agency doesn't carry, they may be able to obtain it from the receiving hospital. If not, it would be prudent to obtain that medication from the pharmacy and have it available for the team.

Finally, consider that transport teams often have limited space and equipment to administer different medications and other therapies. Consider making sure that if patients need different medications that run in using medication pumps (e.g.: antibiotics), administer those medications as soon as possible so they do not take up pump space that may need to be used for other critical medications such as vasoactive drips. When medications are administered, they should be taken down and the tubing disconnected to minimize task load and time at the bedside for transport teams.

In Text References

(Beddingfield FC et al. 1996; Myers and Nolan. 2021; Nolan et al. 2020; Wong, McParland and Nolan. 2020; Neil Holby et al. 2020; Schneider et al. 2017; Ward et al. 2022)

2. 5. 3. Communication and Patient Handoff

Initial communication with the transport team is very important. It is incumbent on the sending provider to not simply discuss the case with the receiving physician, but also provide information to the transport team. While most of the details of clinical management can be discussed at the bedside, it is critical to relay and/or discuss important aspects that may influence specialized equipment that the transport team may otherwise not bring. With advanced notice, transport teams can bring additional or specialized medications they may not typically carry. Furthermore, certain specialty transports require particular equipment that may require modifications to the cabin environment. Finally, safety concerns include know the weight and size of the patient, which may require certain specialized restraining devices.

Any critically ill patient should have a face-to-face report between the provider making the clinical decisions and the team transporting the patient. It is important that the transport team understands certain processes in the decision making and clinical trajectory. Furthermore, for very specialized transport of critically ill patients, receiving providers may have very specific requests for medication administration or to maintain patients within very specific physiologic parameters. This specific guidance may not be within the transport team's standard practice. Therefore, it is important to make them aware of specific, atypical, or special instructions. Also, there are times when typical interventions cause problems or adverse effects. It is important for sending providers to communicate critical information such as this to the transfer team, so they avoid making the same mistake.

For patients that have been unstable or have been very difficult to stabilize, it is also helpful for the sending provider to work collaboratively with the transport teams to anticipate and address active medical problems. The PACE mnemonic may be helpful under these circumstances. PACE stands for primary, alternate, contingency, and emergency plans. An example might look like this:

- **P**RIMARY - "The patient has been hypotensive and refractory to initial fluid resuscitation. We just started norepinephrine. I would titrate this medication to a MAP of 65."
- **A**LTERNATE - "If the norepinephrine reaches a maximum dose of X, and the MAP isn't at 65 consider adding drug C."
- **C**ONTINGENCY - "If the norepinephrine and drug C don't work, this patient may be experiencing Y. It would be reasonable to empirically give the patient drug D under those circumstances."
- **E**MERGENCY - "If the patient suddenly drops their blood pressure, I would immediately do W and consider an emergency bolus of drug Z."

This example is somewhat elementary for most advanced critical care transport teams. However, it serves as an example that can be used in more atypical or nuanced circumstances.

All records and information should be readily available to the transport team. It is particularly useful if the information is organized so the most pertinent and germane to emergency care during transport is on top or immediately available. This might include history and physical exam, procedures, medications, and impressions of key radiology exams. Always include additional copies of radiology reports as well as media that hold the actual images for the receiving hospital to review.

Finally, always ensure that contact information is given to the crew and the transport team's dispatch center. Specifically, the contact information for the receiving physician should be included in the event that anyone involved in the patient's care needs additional information, clarification on treatments, or to provide feedback.

Clinical human factors and patient safety literature has suggested that checklists may be effective tools for patient hand off under these circumstances. In fact, these high-risk circumstances with clinical and logistical complexity are optimal for implementing checklists to ensure critical actions are taken, safety backups are in place, and nothing is forgotten. More will be discussed on checklists in the next section.

A patient with a large vessel occlusion stroke of the left MCA has to be transferred for thrombectomy. After the CT scan the nurse recognizes that the patient is snoring, after assessing the patient you have the following vital signs: AF 8/min, SpO_2 90% with 4l/min nasal cannula, crackles on both lungs, BP 170/105mmHg, HR 78/min, Atrial fibrillation, pupils equal, round, midrange, GCS 2-1-5, hemiplegia on the right side. The helicopter retrieval team has a distance of 42 min. Is a transfer safe under these circumstances?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

Airway and breathing seems to be the problem in this patient, his status is deteriorating, it is highly predictable that the patient will not be able to maintain his airway during the transfer. As such, securing the airway with an endotracheal tube is advisable. It is also important to keep the blood pressure in the recommended range, so for induction a concomitant vasopressor is usually needed. Although intubating the patient costs time, it is helpful to optimize the treatment targets in advance of transportation.

In Text References

(Tian et al. 2020; Eiding, Kongsgaard and Braarud. 2019; Sethi and Subramanian. 2014; Kulshrestha and Singh. 2016; Warren et al. 2004; Wilcox et al. 2022; Huff, Keeperman and Osborn. 2021; Sochet et al. 2018; Garfinkel et al. 2021)

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2. 6. Treating the Patient During Transport

In general, the philosophy of advanced transport programs is that the interval of IFT care is not clinically stagnant. The time in transport is an opportunity for a critical care transport team to continue to progress care and resuscitate the patient. The goal in transport is to continue to address physiologic derangements (within the logistical constraints of the vehicle, supplies, and equipment available) and problems as soon as possible. Ideally, on arrival at the receiving facility the patient would be physiologically optimized for the next step in their care.

Managing patients in transport should, theoretically, apply the same degree of clinical knowledge, decision making, and procedural interventions. Excellent transport teams understand that critical care is not a place, it’s a way of thinking critically to better care for patients. Critical care is the art and science of understanding, on a very intimate level, human physiology and applying the tools and interventions at hand to fix problems with that physiology when it is perturbed by injury or illness.

As mentioned in the previous section, while managing critically ill patients providers should anticipate complications and prepare appropriately. The same is true to the transport team. For the transport team, however, this includes planning for specific events in specific phases of transport. For example, how is the team going to address sudden deterioration as the patient is loaded into the aircraft. During that critical phase of movement, transport team members may have very limited access to the patient and monitoring devices. How is the team going to react if (despite all appropriate precautions and preparations) the endotracheal tube becomes dislodged? How is the team going to respond if an IV carrying critical medications for hemodynamic support is pulled out or infiltrates? The care en route to the receiving facility needs to includes plans for all these emergent situations.

In addition to critical, unanticipated situations, care during transport includes keeping important, scheduled interventions on course. This might include giving additional doses of important medications. For example, if the sending facility has initiated appropriate antimicrobial therapy for patient in septic shock, but the next dose of antibiotics is due during the transport interval, the team should request the mediation from the sending facility and administer it at the appropriate time as opposed to waiting until arriving at the receiving.

Challenge

Pick a patient in your ICU and compile lists of medications and additional supplies you would take with you for intra-hospital and inter-hospital transport. Evaluate the differences. Imagine a technical failure of the ventilator during transfer and how you can solve it.

Anecdote

A mobile ICU team was asked to transfer a 28-year-old morbidly obese male from a regional hospital to a specialist centre. The patient had pneumonia with severe respiratory insufficiency despite maximal mechanical ventilatory support using 100% FiO_2. Despite recruitment maneuvers, clearance of bronchial airways and increasing PEEP and peak pressure, oxygenation did not improve. At the team's suggestion, prone position ventilation was commenced and led to a dramatic improvement in oxygenation. The patient was transported on a stretcher in the prone position with pressure controlled (PC) ventilation, FiO_2 80%, Pmax 38 cm H_2O and PEEP 18 cm H_2O without complications.

2. 7. Clinical Challenges During Transport

2. 7. 1. What May Happen

The population of patients transferred to higher levels of care by critical care transport teams are subject to complication and clinical deterioration. The literature shows that adverse events in transport are not uncommon. Not surprisingly, most complications revolved around airway, oxygenation, ventilation, and perfusion. Oxygen desaturation, atelectasis and derecruitment, bronchospasm, pneumothorax, and accidental extubation have all been reported at rates ranging from 5-28%. Cardiovascular problems including sudden hypotension, persistent refractory shock, arrhythmia, and cardiac arrest have been reported at rates of approximately 1-2% in some studies. While it is difficult to discern if these events had a clear and direct effect on patient outcomes, they remain worrisome in this high-risk population.

Depending on the level of equipment and monitoring (for example, continuous pulmonary artery pressure monitoring), diagnostic clues to the cause of a particular event may be present. If a life-threatening event is unmanageable during transport, it is essential to go to the nearest ICU equipped for the advanced diagnostic and therapeutic procedures required. To find out the next best facility during a life-threatening crisis is difficult and distracts from patient care. It is advisable even for the medical team to have an idea of the route and to map for "exit points".

In Text References

(Droogh et al. 2012; Flabouris, Runciman and Levings. 2006; Papson, Russell and Taylor. 2007; Lyphout et al. 2017; Parmentier-Decrucq et al. 2013; de Lassence et al. 2006; Mazza et al. 2008; Taylor et al. 1970; Damm et al. 2005)

2. 7. 2. Strategies to Address and Prevent Problems

It is worth reemphasizing that before the transport team leaves the safe environment of the ICU, it is crucial to plan for possible deterioration of the critically ill patient by organizing appropriate additional therapy (i.e.: medication, transfusions) to be taken along. Adding therapy for the transfer may be initiated from the ICU team after a pre-transfer-call with the transport team. Even a simple medical intervention such as placement of an intravenous line may be challenging in the close confines of a helicopter or an ambulance.

The need for sending providers and transport teams to anticipate complications has been discussed in previous sections. However, it is important to emphasize that a key piece of combating problems in transport is the ability to share and communicate one's thoughts in this domain. When a healthcare team develops an organized and common understanding regarding these potential problems in transport and how to address them, they build what is referred to as a shared mental model. This model is critical in the prevention and timely, effective response to critical problems in transport.

As mentioned in the last section, the use of checklists may be helpful under these circumstances. Often, these are complex patients with many clinical pieces in play. There is time prior to departure from the sending facility to ensure all critical actions have been taken, the patient is stable enough for transport, and all-important supplies (medications, tubing, back up airway equipment, etc.) are ready for transport. This situation lends itself well to a well-developed checklist.

Anecdote

An ambulance team was called to transfer a pregnant woman with intractable bleeding after laparoscopic cholecystectomy for acute cholecystitis. After several laparotomies, which failed to improve the situation, it was decided that she should be transported to a specialist center for further treatment. However, her blood pressure (90/60, mean 68mmHg) was still dependent on fluid resuscitation including transfusion of red blood cells. What the patient needed was surgery first and admission to critical care later. When the ambulance arrived at the receiving hospital, the patient was admitted directly to the operating room. Careful evaluation, communication, and synchronization made a smooth reception possible; with the operating room, surgeon, anesthesiologist and blood bank ready to play their role.

Note

> Before transporting a patient after resuscitation for hemorrhagic shock, check that red blood cells and other products (platelets, fresh frozen plasma or concentrated factors) are available. However, if testing of blood takes too much time, it is reasonable to administer unmatched products. Remember that cardiovascular stabilization depends more on the amount than on the type of fluid. Do not lose precious time waiting for crossmatched blood products. However, remember that anticipating such a dilemma is the key to avoiding it!

In Text References

(Sochet et al. 2018; Garfinkel et al. 2021; Beck et al. 2019; Westli et al. 2010; Calder et al. 2017; Moore, Squire and Blocker. 2015; Gray, Lauria and Hicks. 2020; Sen et al. 2021)

2. 7. 3. Stabilizing the Patient

The transport team should provide safe and prompt transportation of patients to destination facilities. Traditionally, the literature and common teaching has been that a patient should be "stable" for transfer. This term is relative and should be qualified by the statement "stable enough for safe transfer". The fact is that in this population of critically ill patients they will not all be 100% "stable" when the transfer team arrives. In fact, the patient may not be stabilized until they get to the receiving facility for definitive intervention.

Take, for instance, a patient in cardiogenic shock following in the setting of an acute ST segment elevation myocardial infarction (STEMI). The acute coronary occlusion cannot be fixed at the sending facility. Therefore, the patient will have ongoing ischemic myocardium and potentially sustained cardiogenic shock, life threatening arrhythmias, and hypoxemia until such time as coronary intervention can be accomplished at the receiving facility. Under these circumstances, the benefit of transportation may outweigh the risks given a patient's tenuous and meta-stable physiology.

The converse is true as well. Patients that may not have a time-sensitive pathology or moving toward an evidenced-based intervention that will improve their outcome may benefit from slightly longer time at the bedside addressing issues like hypoxemia or hypotension to ensure a safe transport. For example, a patient with ARDS secondary to COVID-19 pneumonia with refractory hypoxemia may benefit from slightly more time at a small outside emergency department with the transport team optimizing ventilation settings, considering paralysis, attempting initiation of inhaled pulmonary vasodilators, etc. prior to transportation.

Circumstances may arise where further stabilization might actually be possible at the sending facility, but the benefit of certain interventions may not be worth the delay in transport. For example, many sending emergency departments and ICUs can place central venous access or arterial lines. If a critically injured, hypotensive trauma patient is ready for transport from a sending emergency department, it may not be worth the time delay to definitive care to place a central line when the patient has several functional peripheral IVs. Similarly, diagnostic tests such as CT scans or x-rays should not delay transport.

Finally, it is worth commenting that interfacility transportation of critically ill patients is nuanced and the decision of whether or not a patient is "stable enough" can be complicated at times. Under these circumstances other high-risk industries, such as aviation, use what is referred to as the FORDEC cognitive framework to think about these challenges

- **F**ACTS - what is the problem? Refractory hypoxemia? Hypotension? Uncontrolled hemorrhage?
- **O**PTIONS - what options are available? Do we have medications and equipment such that we can address problems in transport? Is the patient so unstable (i.e., in and out of cardiac arrest) that the transport team should stay at the sending facility and continue resuscitation and stabilization?
- **R**ISKS - what are the risks and benefits of the different options?
- **D**ECIDE - the team makes a joint decision on the best, safest option for the patient.
- **E**XECUTE - the team coordinates and carries out the interventions/plan as discussed.
- **C**HECK - the team constantly reevaluates the situation and patient condition. Is the plan working? Is it still safe to proceed? Has the patient's condition improved and there is a window of opportunity for transport?

You are asked to conduct a 45-minute transfer of a 65-year-old man from a small country hospital to a university hospital. The obese, diabetic patient had felt uncomfortable and had experienced tachycardia and dysrhythmia for three days. Although the family physician had noted a subacute myocardial infarction on the ECG, the patient said he felt fine and did not need any help. You note a wide complex tachycardia with a frequency of 150–170 with a blood pressure of 90/60 mmHg (see ECG strip). His oxygen saturation is 88% with a respiratory rate of about 25/min. How do you proceed?

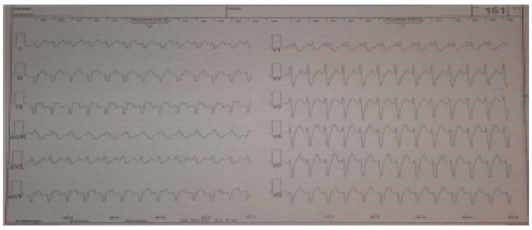

Figure 2:ECG 1

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

This patient was taken to the cardiology suite without prior stabilization where the transport physician was greeted with barely disguised skepticism by the cardiologists. However, when the patient was intubated for cardioversion he developed third degree AV block, (see Figure 3: ECG strip 2) and went into severe cardiogenic shock, necessitating immediate introduction of a pacemaker. An attempt at stabilization before starting the transfer would have led to the cardiogenic shock in the small hospital without the necessary resources for stabilization.

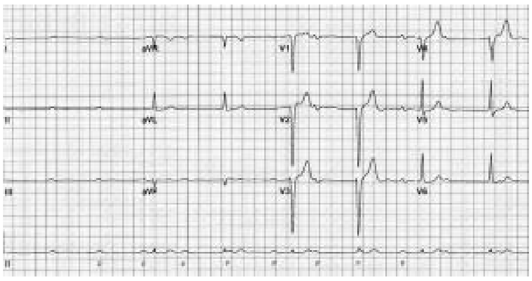

Figure 3: ECG strip 2

Note

If the ability to stabilize a critically ill patient is questionable and definitive intervention at a receiving hospital is possible, transportation with temporizing interventions may be more appropriate. However, there is no universally accepted approach to such patients and personal experience including ‘gut feeling’ is important.

You are asked to conduct a 30-minute transfer of a young pregnant (12th week of pregnancy) woman with suspected pulmonary embolism and cardiogenic shock and a previous history of severe obesity. Shortly after your arrival in the referring clinic the woman requires CPR due to pulseless electrical activity. On handover the physician-in-charge tells you that the woman has recently had laparoscopic bariatric surgery and had suffered from vomiting which was attributed to her pregnancy. A chest X-ray taken just before your arrival shows a complete opacification of the left hemithorax. The patient's hemodynamic status remains severely unstable despite administration of fluids and inotropes. How do you proceed before transfer?

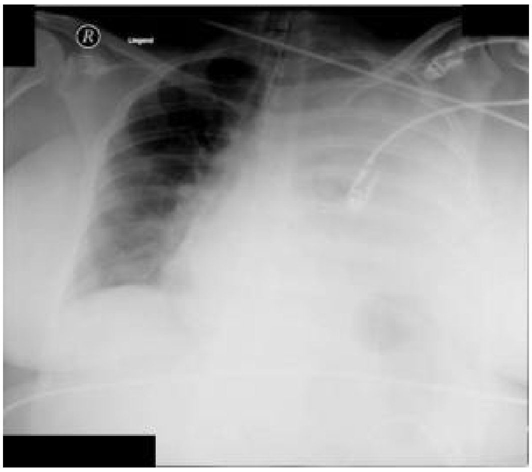

Figure 4: Chest X-ray

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

The transferring (ambulance) physician suspected a fluid filled hemithorax of unknown origin and decided to introduce a thoracic drain. Approximately 3 liters of stomach contents were drained and the hemodynamic situation stabilized immediately. The transfer to the university hospital was then uneventful and the woman survived without sequelae. The decision to 'stay and play' or 'scoop and run' often remains difficult and in this case the decision for action was correct as the patient's hemodynamic situation could not be stabilized. Further investigation revealed that the stomach had herniated through the diaphragm with repeated vomiting and a gastric perforation had occurred leading to a collapse of the left lung, displacement of the mediastinum and cardiogenic shock. Possibly a small laceration in the diaphragm caused by the previous laparoscopic surgery was the initial port for the herniation.

Think

How much time will be saved if an ambulance drives at maximum possible speed for a 40 km transfer between hospitals (e.g.: for transfer of a patient with myocardial infarction) and to what extent will the time saved influence the patient's outcome? In comparison, how could you improve the process of care to save a comparable amount of time? Thus, what are the possible risks and benefits of driving with emergency siren and flashing lights?

In Text References

(Greene. 2009; Chen, Macnab and Sun. 2005; Hatfield, Poirier and Thomas. 2015; Olson et al. 1987; Soll et al. 2016; Hörmann. 1994; Johnson, Lindholm and Dowd. 2006)

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2. 8. Receiving a Patient from the Transport Team

Much emphasis has been placed on the efficiency and safety during the transition of care from the sending facility. However, the reception of a patient at the receiving facility is an equally important transition of care. During these transitions, effective communication and exchange of information are equally important.

Any patient transferred to an ICU by a critical care transport team should be met by the physician or provider that will be in charge of that patient’s care. That individual should interact face-to-face with the team and receive a report that should include the following information at a minimum:

- Patient demographics
- Presentation, workup, and diagnosis at sending facility
- Interventions and therapies administered at the sending facility
- Changes to patient condition in transit
- Additional interventions, therapies, and diagnostics performed by the transport team (e.g., changes to ventilator settings, point of care blood gases, bedside ultrasound findings, titrations of various vasoactive medications, etc.)

- Contact information for sending physician and transport team in case there are questions or concerns after the transfer

After the report, the receiving physician should immediately examine and interview the patient (if possible). He or she should then evaluate critical supportive interventions and settings including ventilator parameters, medication drip dosages, etc. Then, the receiving physician should check to make sure all-important documentation from the sending facility was transferred, including media containing imaging. At that point, any questions can be posed to the transport team before they depart the receiving facility.

At the time of patient turnover and transition to the receiving facility's care, immediate and drastic changes to the trajectory of patient care can be suboptimal and even dangerous (e.g.: shutting off certain vasopressors or inotropes, drastic changes to ventilator settings, complete discontinuation of certain medications). Occasionally, interventions and settings during transport may not be within typical practice of the receiving facility or part of routine, evidence-based care for a particular pathology. These deviations from standard care may have been warranted.

As long as a patient is not acutely deteriorating or in need of emergent intervention, it is best to ask the transport team why certain things were done. There may be a very good reason why certain ventilator modes were selected, or combinations of drugs were administered. The sending facility or transport team may have already tried an evidence-based, widely accepted therapy but a patient did not tolerate it and an alternative was initiated. This is important information for a sending provider to understand. It is therefore reasonable at the time of patient turnover to trust the transport team and continue the therapies and settings they have been using. Once the receiving physician better understands the patient's physiology and clinical trajectory it may very well be reasonable to transition the patient to different analgesia/sedation regiment, change to more appropriate ventilator settings, or gradually switch/titrate different vasoactive medications.

2. 9. Advanced Critical Care Transport Capabilities: Mechanical Circulatory Support

2. 9. 1. Transport of the Patient on Extracorporeal Membrane Oxygenation

Special considerations should apply when considering transport of patients for Extracorporeal Membrane Oxygenation (ECMO). Furthermore, there are slightly different considerations based on the type of ECMO: veno-venous ECMO for lung failure or veno-arterial Extracorporeal Life Support (ECLS) for cardiovascular collapse. Because of the complexity and number of resources needed, ECMO is usually better implemented as a planned, controlled intervention than an immediate dispatch for ongoing CPR. During the COVID-pandemic transfers of patients on ECMO has grown. Teams have had to deal with transport of these highly specialized patients on a more frequent basis.

Clinical judgment of the referring and accepting teams should consider the pros and cons of transporting patients after cannulation and ECMO application (primary transport) or transporting patients on conventional ventilation to start ECMO at the accepting facility (secondary transport). Many factors would contribute to such a decision. That may include but is not limited to severe life-threatening hypoxemia, the risk of further deterioration during the trip and the distance between the two facilities as well as the capacity to perform ECMO in the referring facility. It is also prudent to consider whether the transport ventilator can match the pressures and flow rates necessary to provide adequate oxygenation and ventilation. If a patient is stable on the sending facilities ventilator settings, but the transport ventilator cannot match these parameters, transport may not be possible.

Additional therapies may be considered to safely transfer patients including transition into the prone position or with the use of nitric oxide. These modalities may allow for effective mechanical ventilation without implementing ECMO in the referring hospital, this facilitates transfer and preserves staff resources.

The choice of the ECMO treatment should be carefully considered. Patients who are deemed to have good cardiac function are more likely to be candidates for veno-venous ECMO (respiratory ECMO). Patients with a cardiogenic shock element should be assessed for veno-arterial ECMO and their cannulation planned. The choice of the ECMO center may also be affected by the decision making at that stage with cardiogenic shock patients assessed for heart transplant and preferably transferred to transplant centers. Eventually the decision how and where to implement ECMO is often done without the transport team. So, communication between the ECMO specialists and the critical care transport team is of utmost importance.

It is vital to understand the pathology, the options and the course in the receiving facility. Several factors may influence the mode of transfer (ground or air transport). Time matters in CPR-situations, mostly these patients will go to a cardiac center for revascularization. In the majority the ECLS-team has implanted the circuit in the referring hospital, there may be systems when the retrieval team will bring the ECLS-team to the scene and assist management. A completely different situation is the hypoxemic lung failure, after implanting the circuit, usually in a veno-venous position, it is possible to stabilize the patient on scene and to optimize the status for transfer. Distance is another relevant point. Even though during the COVID-19 surge ECMO centers have grown, it remains a very specialized intervention that is only available at some hospitals. In some countries a team may have to transport a patient more than 200km to reach a center. So even if there is more space in a ground ambulance, a large distance favors air transfer. Long travel times poses some other difficulties in medical gas and drug supply, the ambulance must have an electric converter to spend power, a longer transport cannot be done relying on battery-power. Logistics also play a key role in decision making weather conditions, landing capacity at the hospital or even the patient's weight are important factors.

Globally there is no clear consensus or universally accepted standard for the composition of a cannulation team or ECMO transport team. However, at a minimum an ECMO team may include:

- A cannulating physician/surgeon
- A cannulating physician assistant
- An ECMO/transport trained nurse

The transport team may include:

- A retrieval doctor
- Retrieval paramedics or nurses
- A driver/pilot

While it is not necessary for all team members to be ECMO specialists or have knowledge of pump operation at the level of a perfusionist, all team members on the cannulation team should be familiar with general operation of the EMOC circuit. Furthermore, all team members should be able to assist with or be prepared to manage critical circuit malfunctions (e.g.: unintended decannulation or air embolism). At least one of the team should specialize in circuit management and regularly function as an ECMO specialist.

The equipment needed for an ECMO transport is the same for in-house ECMO along with all the needed equipment for the transport of a mechanically ventilated patient on multi-organ support. Teams should have tailored checklists which should be thoroughly followed before starting an ECMO transport. Teams who are trained to perform air transport should ensure all equipment used is compatible with flights. Local policies should be put in place for air transport.

The referring teams should ensure continuity of care throughout the preparation for the trip including supporting the patient and the team as necessary while ECMO is being applied in cases of primary ECMO. Special needs for the procedure should be communicated between the teams (blood products needed, special medications, etc.).

Families of patients who are to be transferred for ECMO should have special counseling about the treatment and the reason for transfer. Risks and benefits as well as the sensitive and critical decision making should be explained. ECMO teams should ideally start counseling the families before the trip and consent for the treatment should be obtained as per the local policies. Transfer back to the referring facility after the end the treatment may also be communicated if that is the local policy.

The process of transferring patients on ECMO is, without a doubt, more complex than transporting the average mechanically ventilated patient. Therefore, it is important for the retrieval team to have Standard Operating Procedures and training on a regular basis. Even with otherwise very experienced and credentialed transport team members, loading a patient into an air ambulance is tricky and has several pitfalls. Regular practice, drilling, and exposure is important for all team members to maintain competency and proficiency with these very challenging transports.

You are on duty for a helicopter retrieval service and the dispatch center assigns you to a rural hospital where the local ECMO team arrived by a rapid response car some hours ago to cannulate a patient with hypoxic respiratory failure due to a pneumococcal pneumonia. Now you should transfer the patient on ECMO to the tertiary center. You decide to call the ECMO physician before you start. What are important points to know?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

- Patients weight? Will the patient fit on your stretcher and is it possible to transfer the patient in the helicopter?
- Type of ECMO console, what kind of cannulation, is there a licensed mount for the console? Is it possible to store the ECMO in the helicopter, is it crash-proof and are the tubes long enough for loading the patient into the helicopter.
- Ventilation mode and FiO2? Is your transport ventilator sufficient for this patient? Is the amount of oxygen enough? Remember, the ventilator and the ECMO circuit needs oxygen.
- Need for syringe pumps and vasopressor dose? Usually, this kind of patient is sedated and needs inotropes and vasopressors. For helicopter transfer one has a limited number of pumps, so you and the team has to decide what drug is

important and which one can be paused.

- Need for isolation due to infection? Is a separation from cockpit and patients compartment mandatory? Does the team need some protective gowns?
- How many people from the ECMO team want to escort in the helicopter? Are there enough seats? Is there a problem with the weight?
- Do you need some special equipment? Think about the power supply of the machines, some can be powered via 12 or 24V, others need 220V, which can be generated via an inverter.
- Landing site? Is there an appropriate landing site at the hospital? Intermittent ground transfer is tricky with ventilated patients on ECMO and several syringe pumps, it is easier to load the patient direct into the aircraft.

Figure 5: DRF Stiftung Luftrettung gAG: ECMO-training with the Getinge Cardiohelp®.

In Text References

(Extra Corporeal Life Support 2015; Broman et al. 2015; Lucchini et al. 2014; Brown et al. 2022; Hutin et al. 2021; Broman and Frenckner. 2016; Niziolek, Preston and Osborn. 2017; Vieira et al. 2020; Benson et al. 2021; Gottula et al. 2022)

2. 9. 2. Other Mechanical Circulatory Support Devices

There are other mechanical circulatory support devices, specifically Intra-aortic Balloon Pump (IABP) and Impella®, that are commonly transported. The principles mentioned in the ECMO section (familiarity with equipment, mission planning, use of checklists) are applicable, too. Proper preparation, focused communication with the specialist team, evaluation of special needs (power, gas supply, seating position) and training with the devices are all requisite. Specific Standard Operating Procedures or Clinical Guidelines should be developed for every special device. With preparation, training, education and quality assurance processes, critical care teams can safely and effectively transport any mechanical circulatory support device.

In Text References

(Benson et al. 2021; Gottula et al. 2022; Sen et al. 2016; Griffith and Jenkins. 2010; Oesterling, Bott and Davis. 2022; Sinclair and Werman. 2009; Mertlich and Quaal. 1989; Burns, Reid and Habig. 2013)

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3. Considerations for Intrahospital Patient Transport

Intrahospital patient transport (IHT) is an important, common daily occurrence. Many patients from the critical care units of the hospital travel to the OR, interventional radiology, cardiac catheterization lab, and radiology for different studies and interventions. Although seemingly less dangerous and complex as moving a patient hundreds of miles via aircraft, IHT requires similar attention to patient safety, communication, and coordination.

Critically ill patients in general are at increased risk of morbidity and mortality during any form of transportation. Authors have reported rates of minor adverse events as high as 68%. Incidence of critical events requiring emergent therapeutic interventions are reported to be lower at 4.2-8.9%. While this number is significantly lower, it is certainly not insignificant. Finally, cardiac arrests during IHT rates range from 0.34-1.6%. It has been further documented that the number of adverse events is disproportionately higher (42.5%) during the initial movement from the emergency department up to the ICU. Thus, it is apparent that simply moving a critically ill patient to radiology for non-emergent imaging may not be completely benign.

Studies have examined risk factors for IHT patient deterioration. These risk factors are generally divided into four categories: equipment, team members, organization, and patient severity. Interestingly, patient severity has minimal predictive value and a weak association with adverse events. The vast majority of incidents related to equipment malfunction, human factors, and policies/procedures. Often these adverse events demonstrate overlapping features of these categories. For example, a mechanical ventilator malfunctions and fails to deliver appropriate tidal volumes and no specialist is available to trouble shoot the ventilator. This is a combination of both equipment and team member risk factors. Common themes across these categories are problems with medication pumps/drips, mechanical ventilation, airway, maintaining appropriate sedation, loss of situational awareness of monitoring parameters (e.g.: staff not seeing EtCO2 suddenly drop or arterial line blood pressure decrease), and communication issues between hospital staff/departments.

Given the strongest association with modifiable risk factors a number of institutions, clinical organizations, and patient safety specialists have developed guidelines to improve IHT. In fact, several authors suggest that with proper equipment, training, procedures, and communication IHT can be safe regardless of patient severity or degree of organ failure.

Best practice in terms of maximizing patient safety suggests numerous organizational developments. First, specialized teams should be developed for IHT. Regardless of personnel involved (physician, nurse, respiratory therapist, or other allied health profession), the team should be specially trained to move and manage these patients outside of the emergency department and ICU. It should consist of 2-3 people who can perform all the functions of ICU level support (titrated drips, sedation, troubleshoot mechanical ventilator settings, etc.). Some authors have recommended a specially trained physician accompany all high acuity patients. With a physician that knows the patient very well and is specially trained in transport, the team has the advantage of an individual with the knowledge, clinical decision-making privileges, and technical skills to address nearly all adverse clinical situations.

There is near universal agreement that the IHT team should have specialized equipment to perform the transport. The equipment should be able to fit in a small bag, backpack, or trolley such that it is easily mobile. It should contain ready access to emergency airway equipment, critical care medications, and tools for emergency interventions (scalpel, thoracostomy tray, etc.) as well as advanced portable diagnostic tools like point of care ultrasound (See Figure 6 and 7). In addition, back up equipment should be added to the set of IHT equipment, such as extra batteries, extension cords, oxygen port adapters, or extra oxygen cylinders.

Figure 6: Pictures of an IHT response bag organized and equipped with emergency medical equipment.

Figure 7: Pictures of an IHT response bag organized and equipped with emergency medical equipment.

Standard operating procedures should be in place for IHT teams during patient movement. These procedures should include clear, agreed upon criteria for terminating the transport or diverting to particular areas of the hospital in case of emergency. In addition, they should include delineation of standard duties including who is primarily in charge of monitoring hemodynamics and who primarily is in charge of managing the ventilator.

Communication between the sending unit and receiving unit should be clear and structured. The receiving unit in the hospital should always be made aware of the patient movement and possible key logistical information (e.g.: if the patient is mechanically ventilated or has a mechanical circulatory support device). Communication among the IHT team is critical also. Several authors recommend using an IHT checklist similar to those used in IFT. Given that many of the adverse events are linked to things like equipment (e.g.: battery failure, malfunctions, etc.) and communication short falls (e.g.:

failure to contact and coordinate with the receiving unit), normal checklists seem to be an excellent solution. In fact, one study reported up to 91% of avoidable adverse events were caught by a systematic checklist implementation.

3. 1. Intrahospital Special Clinical Environments

There are special facilities in a hospital which poses some risks as well to the patient as the transfer team. For example, if the transport team is expected to transfer a patient to the cardiac catheterization lab, it is prudent to make sure that appropriate lead gowns (inclusive thyroid protection) are available to minimize exposure.

Special arrangements must be made when in close proximity to MRI scanners which produce magnetic fields several times greater than that of the earth. All ferromagnetic material is attracted by such magnetic fields, which are active even when no scans are being performed. Transfers for MRI scans require specially designed, non-ferromagnetic equipment, which is usually available in/near the MRI suite. A less satisfactory alternative, using standard equipment secured outside the range of the magnetic field with long hoses and monitoring leads to the patient, may be used in some scanners

Before starting a transfer to the MRI suite, what limits and contraindications must be considered?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

An absolute contraindication is the presence of ferromagnetic material in or on the body since it may vibrate, become hot or dislodge. For example, freshly implanted metal stents may be dislodged. Extra-corporeal metal such as ECG leads or splints used to secure an intravenous line may become hot enough to cause burns. Nowadays many implanted materials are non-ferromagnetic and thus compatible with MRI.:A

In many institutions it is the responsibility of the staff requesting MRI scanning to determine whether foreign bodies are compatible. Theoretically, information concerning MRI compatibility must be obtained for every single foreign body from the manufacturer. In everyday practice this is often not feasible, because it is unknown which device precisely is implanted, e.g.: which model of a hip prosthesis. Based on clinical experience most implanted devices, such as stents or prostheses, without electronic control are suitable for MRI. Electronically controlled devices, such as pacemakers or infusion pumps, may not function properly during and after MRI and a need for their presence precludes MRI scanning. It is worth mentioning though that a recent study showed no significant impact on pacemakers with non-thoracic MRI examinations in a 1.5 Tesla MRI. Standard medical devices such as ventilators or infusion pumps are not compatible with MRI and special arrangements/equipment must be used. Sometimes the patient has to be switched from transfer equipment to the equipment in the MRI suite. Make sure that the team is trained in working with the MRI monitor and ventilator. Before the patient is moved into the scanner, a check should be performed to determine if there is still an incompatible device present (e.g.: a tracheal cannula with metal). After the patient is checked, the transfer staff must be assessed as well, as it is quite common to have pens, scissors, telephones or a stethoscope in uniforms, so one the staff will either have to change clothes or to empty their pockets.

Additional considerations need to be made for clinical logistics. Extensions for ventilator tubing and IV tubing make for additional points of failure or disconnection. Elongating ventilator tubing to reach a patient from outside the MRI machine adds additional dead space and resistance in the circuit. Additional extensions in the IV tubing may delay time for infusions to take affect or boluses to be delivered. A plan should be established as to how to proceed if there is a medical incident during scan time, such as the need for suctioning or respiratory depression in sedated patients. A clear plan of action should also be in place for emergent situation like cardiac arrest to ensure staff safety while facilitating rapid access and initiation of care for the patient.

A relative contraindication to MRI is claustrophobia due to the narrow space inside the scanner and sedation or even general anaesthesia may be required for susceptible patients.

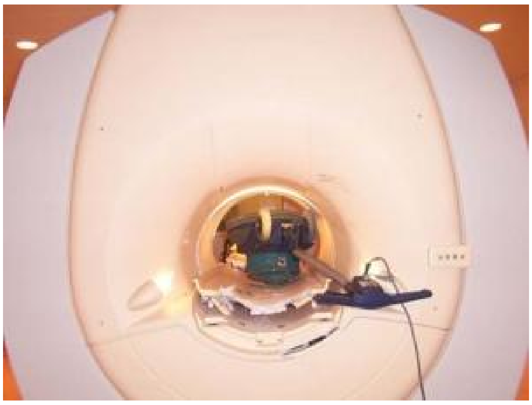

Figure 8: A metal object is placed in the MRI environment. Reproduced with the permission of the Academic Medical Centre, University of Amsterdam, Department of Radiology © 2004.

The figure 8 above demonstrates an example of what can happen when a metal object is placed in the MRI environment: In this case, a cleaner entered the MRI scanner room with a polishing machine. Fortunately, no patient was being scanned at the time as the patient trolley of the MRI was completely destroyed.

In Text References

(Russo et al. 2017; Kulshrestha and Singh. 2016; Warren et al. 2004; Salt et al. 2018; Fanara et al. ; Beckmann et al. 2004; Caruana and Culp. 1998; Damm et al. 2005; Doring et al. 1999)

(Ferdinande. 1999; Gillman et al. 2006; Haupt and Rehm. 2000; Shirley and Bion. 2004; Lahner et al. 2007; Lovell, Mudaliar and Klineberg. 2001; Papson, Russell and Taylor. 2007; Fan et al. 2006; Bellingan et al. 2000; Uusaro et al. 2002)

(van Lieshout et al. 2008; Beyer AJ, Land and Zaritsky. 1992; Burtnyk. 1992; Edge et al. 1994; Gebremichael et al. 2000; Greco. 1990)

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4. Conclusion

Moving patients between facilities or within the hospital is challenging and complicated. Furthermore, in both instances there is significant risk to the patient and relatively high rates of adverse events. It is paramount that proper preparations are made that address the clinical aspects, logistics, and operations of transport. In both instances it is recommended that teams with specialized training and equipment be used to transport patients to ensure optimal safety and efficiency.