Patient Transportation Part I: Introduction to Transportation of the Critically Ill or Injured Patient

Table of Contents

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Authors

Michael J. Lauria MD, NRP, FP-C, *EMS and Critical Care Medicine Fellow; Flight Physician and Associate Medical Director, Lifeguard Emergency and Critical Care Transport; University of New Mexico School of Medicine*

Pierre Marc Dion BScN, RN, *Emergency, Critical Care and Flight Nurse; MD Candidate, Faculty of Medicine, University of Ottawa, Ontario, Canada; Royal Canadian Medical Services, Canadian Armed Forces.*

Reviewers

Michael D. Christian MD, MSc, FRCPC, DRCPSC, CCPE, *Chief Medical Officer – Chief Medical Officer: BC Emergency Health Services, Provincial Health Services Authority; Clinical Professor - Division of Critical Care Medicine, Department of Medicine, University of British Columbia*

CoBaTrICE Mapping Contributor

Cristina Santonocito MD, *Dept. of Anesthesia and Intensive Care, IRCSS-ISMETT-UPMC, Palermo, Italy*

Victoria Anne Bennett MD, MBBS, FFICM, FRCA, *Anaesthetic and Intensive care registrar, University Hospital Lewisham, London, United Kingdom*

Executive Editor

Nathan D. Nielsen MD, MSc, *Associate Professor, Division of Pulmonary, Critical Care and Sleep Medicine, University of New Mexico School of Medicine, Albuquerque, United States; Editorial Board and Sepsis Section Editor, ESICM Academy*

Intended Learning Outcomes

Patient Transportation Part I: Introduction to Transportation of the Critically Ill or Injured Patient

1. List indications for inter-hospital and intra-hospital transport
2. Weigh the risks and benefits of patient transport in the context of individual pathologies and patient condition
3. Describe ethical considerations for patient transport
4. Understand potential complications that can occur during transport and how to mitigate them
5. Explain important pre-transport interventions to stabilize patients for transfer
6. Outline the different transport team models and their capabilities
7. Identify important clinical parameters to be monitored during transport
8. Recognize the capabilities and limitations of equipment used in the transport environment

eModule Information

Relevant Competencies from CoBaTrICE

Patient Transportation Part I: Introduction to Transportation of the Critically Ill or Injured Patient

- **1.4** Triages and prioritises patients appropriately, including timely admission to ICU
- **10.1** Undertakes transport of the critically ill patient outside the ICU (intra-hospital as well as inter-hospital)
- **11.4** Identifies and minimizes risks of critical incidents, adverse events and complications

1. Introduction

Transportation of the critically ill patient is inevitable in most health systems. Prehospital transportation (PHT) may be necessary after major injury or as a result of life-threatening illness – for example, myocardial infarction, intracranial hemorrhage, or metabolic coma. This mode of response and transport specifically refers to patients that are outside of a medical facility and are being mobilized to an emergency department for initial triage, resuscitation, and stabilization. There are some exceptions to this as patients are occasionally brought from outside the hospital directly to other destination areas of the hospital such as the cardiac catheterization lab or operating theater for definitive management.

Intrahospital (IHT) and Interfacility (IFT) transport, in contrast, refers to patient transfers within an institution or between institutions. Reasons for transportation may include a diagnostic procedure (e.g.: CT or MRI scan), a therapeutic intervention not available at their original location or for tertiary critical care or even transfer to early rehabilitation facilities. The increasing cooperation between medical institutions and specialization of institutions – such as the sharing of intensive care units or diagnostic devices and bed availability and/or organization – is likely to increase the need for transport of critically ill patients. This increased need might also be stimulated by the ongoing debate over whether high volume centers have potential clinical outcome benefits.

In some areas of the world this area of expertise is referred to as Prehospital and Retrieval Medicine (PHRM). This term, which perhaps better describes the direction of the specialty, places emphasis on highly-trained retrieval teams that deliver a higher level of care to outside facility and bring to bear the full clinical knowledge and skill necessary to progress care in the transport interval. This stands in contrast to other terms and antiquated team designs that provide safe and adequate patient movement, but optimal care is delayed until arrival at the accepting facility.

It is worthwhile to mention that this terminology uses additional terms that more specifically define the role of the retrieval team and the geographical destination location and destination someone what differently. “Primary retrieval” is similar to PHT: responding to a location outside of the hospital to provide primary resuscitation with other prehospital profession and movement to an appropriate receiving facility. “Secondary retrieval” refers to missions where the patient is at a smaller hospital with very limited access to specialty care where the patient will likely need additional resuscitative measures and specialized care from the retrieval team. “Tertiary retrieval” is between facilities where the sending facility does have various specialty services and generally has already stabilized the patient, but they do not have select clinical services only available at large regional and academic centers (e.g.: neurosurgery or transplant services). Finally, “Quaternary retrieval” deals with long-distance patient transfers such as repatriation or international transfer.

The term Critical Care Transport (CCT) refers specifically to the skill level and capability of the transferring team. CCT utilizes specialized teams that provide advanced capabilities to resuscitate, optimize, and transport patients by way of ground, air, or water-surface from a sending facility to a receiving tertiary or quaternary center. CCT teams generally operate to provide both prehospital and interhospital transportation services. While composition, training, and equipment of CCT teams vary widely across the world, they can generally provide medical care intensity and quality that would be at the level of the receiving facility.

Around the world, regionalization of specialty care services for critical care, stroke, ST-segment myocardial infarction, trauma, pediatric, and neonatal care has demonstrated improved quality and reduction in practice variation. This trend has resulted in substantial advances in medical care but has required more than patient movement to these destination centers. Transportation of a critically ill patient requires the ongoing delivery of organ support in an unfavorable environment. Moreover, as mentioned above, the paradigm of PHRM and CCT has evolved to focus on care delivery at the point of patient contact. This expertise is critical in both preventing patient deterioration in transport and enhancing the quality of care. As a result, the need for various transport modalities and highly trained specialty teams has increased. Therefore, it is important for clinicians to understand patient transportation.

Failure to prepare both the patient and the transport team may lead to suboptimal delivery of care to the patient. This may constitute a threat to the patient and lead to avoidable adverse events and such experiences may lead to stress and possibly post-traumatic stress disorder in caregivers. Thus, risks and benefit of a transfer must be assessed during the planning phase, which must include:

- Appropriate assessment of the patient’s condition
- Assessment of the perceived risk versus benefit of the transfer
- Initiation of appropriate support including the staff and resources, to achieve resuscitation and best possible stabilization
- Checking of transport equipment
- Using adequate transport equipment (e.g.: mobile intensive care ventilator)

The principles of transport are very similar for prehospital, interfacility or intrahospital settings. It is particularly important that the expected benefits of the transfer for the patient are identified. This way, the appropriateness of the transfer can be assessed and balanced against the risks.

This module focuses mainly on adult transport. However, the principles of transport are the same for neonatal and pediatric patients. In this module, hospitals sending patients elsewhere will be described as referring (or referral) hospitals while those receiving patients from outside will be termed receiving hospitals.

2. Approach to Transfer of Critically Ill Patients: Risks versus Benefits

The risks of transport should be offset by an expected benefit for the patient. Every transport needs a clear indication and if the patient deteriorates during transport, it may be necessary to abandon the trip and withdraw to the safety of an intensive care unit (ICU) (‘Plan B’).

Although there are differences between pre-, intra- and interhospital transfer (such as: indication, duration of transport, environment of transport, availability of help in the event of a complication, lighting, available space for work, equipment, and others), the main considerations and principles for preparation are similar.

Inter-hospital transfer is often referred to as secondary transport and alludes to patient transfer from one health care institution to another. Intra-hospital transfer relates to patient transport within an institution, e.g., transfer of a patient from the ICU to a hospital diagnostic suite.

If an ICU bed is not available within an institution, a patient may be stabilized in the Emergency Department or the Operating Theater while IFT to another facility is arranged. It is reasonable at this point to discuss treatment strategies with the accepting provider at the destination facility. Furthermore, it may be prudent to summon a critical care or specialty care transport team for assistance with management even though a bed is not available. Occasionally, rural facilities may be extremely limited with staffing and equipment. Under these circumstances, transport teams can assist in resuscitation, stabilization, and optimization of the patient. They can bring specialized equipment, additional medications or blood products, and even specialized personnel to perform invasive resuscitative procedures at the sending hospital.

It should be emphasized that IHT of an intensive care patient may pose fewer risks than an IFT because the safe environment of the hospital is not abandoned. However, you could for example be stranded in the radiology department with a non-functioning gas supply. Accidental dislodgement of intravenous lines or endotracheal tubes may happen in any environment, such as hospital corridors or within an ambulance and are always an acute emergency. Further specific risks may be encountered in IHT (e.g.: in the MRI suite) which are not an issue in IFT. In fact, studies show similar rates of adverse events in IHT and IFT. Thus, the potential safety issues of IHT should never be underestimated. Providers must be prepared for the worst-case scenario and consider similar risks in IHT just as much as IFT.

Patient transport is a clinical skill like placing a central venous line and requires a rigorous training process, robust guidelines, as well as strong quality assurance. Only experienced and trained staff should accompany a critically ill patient. Benefits and risks should be weighed in every critically ill patient before transport.

Note

> Sometimes the youngest resident is sent on patient transport. This is suboptimal allocation of human resources and may suggest that those responsible for allocation of personnel have little experience themselves in patient transport and may not be aware of the possible risks. Proper ‘hands-on’ training, perhaps with competency certification on the use of the transport equipment should be provided. Such training should include a number of transports executed under supervision. Special attention to airway training and the level of airway experience should be considered and tailored to individual patient transfers. The team should be able to deal with common complications, e.g.: venous line dislodgement, hemodynamic instability or problems with ventilation.

Anecdote

A young woman suffering from non-Hodgkin lymphoma developed progressive respiratory insufficiency. Due to her neoplasm, severe secondary amyloidosis was noted, including amyloid cardiomyopathy and extensive deposition of amyloid fibrils in her skin and oral cavity. Her respiratory rate was above 30 breaths per minute and plethysmographic oxygen saturation was around 85%. A 40-minute transfer was planned to a university hospital. Upon notification the physician at the receiving hospital suggested intubation of the patient before departure. However, the referring physician advised that mechanical ventilation is unnecessary as this was the patient's chronic medical condition and the transport was started with two paramedics. However, the patient's condition rapidly deteriorated and the patient died during transport. In addition to the apparent tragedy to the patient, this episode caused severe psychological distress to the transport team, who were not trained to transfer such a patient. The situation was poorly assessed by the referring physician. Better planning might have saved the patient's life and/or prevented distress for the transport team.

> **Note**
>
> Local arrangements and protocols are normally in place to ensure that there is clarity regarding the identification of the physician/team responsible for the transport. A call before starting the job is worth performing to obtain additional information regarding the required care and the plans from the referring doctor.

In Text References

(Droogh et al. 2015; Intensive Care 2011; Wilcox et al. 2022; Seymour and Kahn. 2017; Kiss, Bölke and Spieth. 2017; Martin. 2012; Association of Critical Care 2016; Carr, Matthew Edwards and Martinez 2010; Magdon-Ismail et al. 2017; Ranney et al. 2017)

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2. 1. Indications for Transport in Critically Ill Patients

- The need for additional technical and professional expertise e.g.: neurosurgery, interventional radiology, percutaneous transluminal coronary angioplasty, continuous renal replacement therapy, organ transplantation, and specific critical care interventions such as mechanical ventilation in prone position.
- Organizational aspects may have an influence e.g.: lack of available beds, massive influx of patients.
- “Step-down” transfers from specialist centers to smaller hospitals or rehabilitation facilities
- Due to increasing options for diagnostic and therapeutic interventions outside the ICU, there is a growing need for intra-hospital intensive care transports to places such as the CT, MRI, angiography suite, radiation therapy department or the operating room.
- Depending on the local situation; for example, a small rural hospital versus a large specialist center – the frequency of IFT ICU transfers will vary considerably. But even in large specialist centers IFT may still be indicated in some circumstances (e.g.: transfer for organ transplantation).
- Potential benefits should be discussed by senior ICU staff members and any other relevant experts before a decision to transfer is made.

Why might an inter-hospital transfer between large specialist centers be indicated?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

Not every tertiary center specializes in the same services. For a liver transplant or coiling of an intracranial aneurysm, inter-hospital transfer may be the only way to ensure that an ICU patient receives appropriate care. Furthermore, lack of availability of ICU beds is common in some jurisdictions, sometimes more common in larger units.

2. 1. 1. Ethical Considerations

Lack of ICU resources as a reason for IFT may pose an ethical dilemma for the entire team. A medicolegal consideration could be the existing doctor–patient relationship established with other patients before the last patient was admitted. In that case the rule ‘last in first out’ is sometimes applied.

However, as ICU physicians, we are not only responsible for a single patient, but for the entire cohort of ICU patients and potentially, all patients within the hospital and health system. Therefore, another approach might be to choose a less critically ill patient in the unit to be transported to another institution within a network of ICUs. This might constitute better allocation of overall ICU resources regionally. Such decisions are difficult and should be taken after senior discussion with the interests of the patient involved as the primary consideration.

Such a situation requires cautious communication with other members of the medical team, e.g.: surgeons, and with family members who may focus only on their individual relative. The transfer creates the problem of exposing a patient to risks of transport without evident benefit to that individual, other than the patient being looked after at a more appropriate (or sub-specialised) level of ICU. A dedicated system such as a mobile intensive care unit (MICU, including specialized team and equipment), if available, should minimize the risks especially in these situations.

Note

If an investigation requires intra-hospital transport, always consider whether the results will have clinical consequences. Often, a procedure can be postponed. It may be possible (and much safer) to perform such an examination if the patient is requiring less organ support. Often, the physician ordering a diagnostic or therapeutic procedure outside the ICU does not accompany the patient during transport and may be unaware of the associated risks. Thus, they cannot fully perform a risk/benefit analysis for transport without advice.

With the introduction of digital picture archiving and communication systems (PACS) radiographic images may be transferred electronically, rather than transferring the patient.

Anecdote

An 82-year-old man was admitted to a small hospital. He had a GCS of 5 after suffering a severe intracranial bleed and was quickly transferred to a university hospital. When the patient arrived at the emergency department of the university hospital, the neurosurgeon refused any intervention based on the patient's CT scan, age, and clinical presentation, and demanded that the patient be transported directly back to the referring hospital. Better communication between the two hospitals would have made the transfer unnecessary.

In Text References

(Crocker et al. 2010; Venkat, Huckestein and Dhindsa 2015)

2. 1. 2. Risks of Transporting Critically Ill Patients

- Technical complications: e.g., displacement of the tracheal tube, intravascular lines, drains, etc.
- Providing care with limited light, limited space, excess noise, and vibration from transport vehicles.
- Environmental challenges including precipitation, extremes of temperature, and other factors
- Pathophysiological deterioration: e.g.: increased intracranial pressure (as may occur from the lowering of a head-injured patient from semi-recumbent to recumbent position for a CT scan), arterial hypotension, decrease in oxygen saturation.
- Limited monitoring of cardiovascular and pulmonary function due to less sophisticated monitors or equipment/interference due to motion, etc.
- Limited equipment (e.g.: syringe pumps, drugs or even gases like oxygen or inhaled nitric oxide (iNO))
- Suboptimal therapy due to lack of appropriate equipment – some transportation ventilators cannot deliver the modes or levels of ventilation as a high-end ICU ventilator. (Note: newer ICU ventilators may be used for transport and are even becoming MRI compatible.)
- Additional movements during transport such as acceleration forces during aeromedical or ambulance transport, or tilting/lifting of patients from bed to trolley may cause dislocation of fractures, fibrin clots, sutures, vascular emboli, etc..
- Reduced immediate access to additional investigations or therapy if needed. For example: no chest X-ray in an ambulance to diagnose/exclude a pneumothorax or extra unit of packed cells/clotting factors in case of acute hemorrhage.
- Limited number of people involved in the transport, lack of specialists immediately to hand.

Clinical studies on ICU transport have noted an incidence of up to one technical and/or clinical adverse event per transport. These events may be preventable and relate to equipment, communication, planning etc. Other investigations indicate that major adverse events such as desaturation, worsening shock and other major clinical events range from 5 – 28%. It is unclear to what degree these events may be preventable given the very nature of the critically ill or injured population being transferred, but understanding the transportation environment may help sending and receiving providers better plan for and mitigate these events.

Note

Is the transport team familiar with a planned intervention, e.g.: in interventional radiology? Not all ICU nurses or physicians will always know what to expect. Some interventions such as digital angiography need to be performed under apnea, i.e.: involving the use of muscle relaxation. A lack of medication and material may lead to a delay in the intervention. Is the transport team able to perform vital treatments, e.g.: a pericardiocentesis in worsening pericardial effusion?

Challenge

Does your organization or those you interact with use special paperwork or documentation for transport? Study the transport documentation for the last five patients transported within your hospital or between hospitals. Were there critical incidents during transport? How serious were they (minor or potentially life-threatening)? Could these critical incidents have been anticipated, and possibly avoided, with better planning? Be aware of under-reporting of critical events. Even though automated documentation of vital data and machine settings can be captured using a patient data management system (PDMS), such systems are only starting to be used outside the ICU.

Check your own equipment for ICU transport. Imagine clinical situations in a radiology room which you might not be able to handle, forcing you to return to the ICU. Consider updating or expanding the material on your transport unit.

Note

With sufficient preparation and good equipment, transport of severely ill patients, even in prone position, is possible without an adverse event.

Which patients and situations face an increased risk of adverse events during transport, and why?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

- Pediatric patients: even small movements of the patient or associated equipment (e.g.: endotracheal tube) may lead to disconnection or dislocation of the tubes and lines.
- Transfer during off hours: this may mean fewer staff or staff with less experience resulting in sub-optimal planning and preparation of conduct of transfer. Poor lighting may impair tasks and make correct dosage of medications or the recognition of complications more difficult.
- Patients with increased intracranial pressure: often it is not possible to elevate the upper body for transport and positioning of the patient, e.g.: in the CT or MRI suite.
- Patients with increased positive airway pressure during ventilation: many transport ventilators will not generate enough driving pressure or PEEP to sufficiently oxygenate very obese patients or those with severe ARDS.

- Abrupt change of clinical team: information may be lost if the transfer team has no connection with the team previously providing care and has not had sufficient time to get a proper clinical picture of the patient. Every handover of information poses the risk of information being lost.

What should be done before transport to minimize the risk of critical events during transport?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

Adequately stabilize the critically ill patient. Use checklists and guidelines. It is safer to intubate and mechanically ventilate a patient in respiratory distress in the ICU before transport than to wait for clinical deterioration and be forced to perform intubation in an elevator, ambulance or aircraft. The same holds true for starting vasoactive agents and, therefore, gaining central venous access.

Anecdote

A patient in cardiogenic shock at a local hospital was scheduled for a transfer of approximately 60 miles (90 km) to a university hospital, after the nearby receiving hospital declined to accept the patient due to lack of the specific resources required for the patient. Despite a poor weather forecast, the referring physician ordered a helicopter transfer, and the patient left the hospital with the helicopter team. The pilot in charge first considered weather conditions acceptable. However, after 15 minutes the weather conditions worsened, the clinical status of the patient deteriorated, and the transfer was abandoned. The patient died shortly after returning to the referring hospital. Discussions held subsequently suggested the need for better communication with the nearby receiving center, including the use of triage and prioritization of all patients/referrals. This might have made the longer transport unnecessary, eliminating an additional risk for the air transport team.

In Text References

(Droogh et al. 2015; Droogh et al. 2012; Flabouris, Runciman and Levings. 2006; Papson, Russell and Taylor. 2007; Evans et al. 2016; Lyphout et al. 2017; Singh et al. 2009; Singh et al. 2009; Bérubé et al. 2013; Sablot et al. 2020; Wilcox et al. 2015)

2. 1. 3. Guidelines for Appropriate Interfacility Transport

Many critical care medicine societies and specialty training bodies have guidelines dealing with indications for transport of critically ill patients. Some guidelines make concise recommendations for staffing and equipment. They are available online:

- The Intensive Care Society (United Kingdom) – Guidelines for the transport of the critically ill adult (3rd Edition 2011)
- Australasian College for Emergency Medicine, Australian and New Zealand College of Anaesthetists; Joint Faculty of Intensive Care Medicine. Minimum standards for intra-hospital transport of critically ill patients 2015.

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- German interdisciplinary association for intensive care and emergency medicine: Recommendations for staffing interhospital transfer of critical ill patients.

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- Flabouris A, Runciman WB, Levings B., Incidents during out-of-hospital patient transportation., 2006, PMID:16617646
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3. Planning the Transfer of a Critically Ill Patient

The large majority of incidents relating to patient transportation are preventable with adequate planning. Careful and thought preparation should be taken prior to transfer. Sending providers should coordinate with the receiving specialist and transport team. This includes choosing the appropriate mode of transport as well as understanding the transport team equipment and capabilities. In addition, it should involve comprehensive communication, briefing, and logistical support for the transport team.

3. 1. Deciding to Transport the Patient

The decision to transfer a critically ill patient to another facility should be made jointly by the referring and receiving critical care physicians. This decision is influenced by multiple factors:

- The course of the disease, the tendency toward improvement/deterioration, and the expected benefit for the patient from advanced treatment in the receiving center.
- Staffing for transfer: medical and paramedical. Seniority of the staff and their experience are additional key issues.
- Logistics: equipment, resources, e.g.: patient weight/weight limit of stretchers, size capacity of CT trolley.
- Transport conditions: distance, route, weather.
- Alternative modes of transportation, e.g.: fixed wing aircraft rather than helicopter in poor weather conditions, mobile Intensive Care Unit (i.e.: specialized ambulance) rather than helicopter when bulky equipment such as intra-aortic balloon pump is required for transfer.

> **Note**
>
> Even if a critical care patient is in severe cardiogenic shock due to ongoing myocardial infarction, the expected benefit of primary percutaneous coronary intervention could outweigh the high risks of inter-hospital transport. The balance between time consuming pre-transport stabilization and delaying the intervention is crucial.

Every transport poses an additional risk to the critically ill patient. If there is any doubt, the risk-benefit analysis must be reviewed with the senior member of the transport team, who carries final responsibility during transfer. Furthermore, transport programs systems have comprehensive systems in place to assist sending teams in logistic and clinical decision. These systems go beyond coordinating patient movement and also provide pre-transportation clinical recommendations, triage advice, and even tele-assessment. This will be discussed further in Part II of the Patient Transportation Course.

Immediately before commencing the intra-hospital transport of an ICU patient to the operating room or the radiology department, make a final phone call to ensure that the department is still ready to accept the patient as planned. Sometimes emergencies in the receiving departments make the acceptance of an ICU patient impossible despite prior arrangements, possibly made hours before. With an unstable patient, have somebody reserve elevators and check that hallways are clear.

Lengthy procedures in the radiology department require even more meticulous preparation. Sufficient medication and fluids should be on-hand. Blood gas or other laboratory analysis should continue if required provided there is adequate assistance for transport of blood samples.

A so-called ‘time out’ of the transport team before departure has successfully been used as a security check. Items on a checklist would include the following:

- Patient's name and complete list of diagnosis including reason for transfer.
- Complete documentation including radiography, laboratory, patient's chart.
- Exact location of the destination e.g.: the receiving unit within the receiving hospital. Also, the shortest route from the landing pad/ambulance park to the unit or assignment of an escort to accompany the transport team.
- Final check of weather condition with respect to road/air transfer and planning of alternative transfer route/medical institution.
- Name, position and phone numbers of the senior physician responsible for the transfer and also the responsible physician at the receiving hospital, who will take over the care of the patient.
- Checking of all medical equipment for transfer including advance planning in case of deterioration. Advance preparation of medication and syringe pumps will be easier in the warmth of an ICU as compared to the close confines or a shaky helicopter or ambulance cabin with possible poor lighting.
- Duration of the transfer and subsequent calculation of supply of medical gas, medication and other equipment.
- Advance knowledge of 'Plan B' with subsequent necessary medical equipment and medication.

Even though many of these tasks are the clear responsibility of a defined team member (road conditions for the driver, medical condition for the physician) it is of mutual interest that the entire team is aware of the risks and alternative possibilities of the transfer.

Creating a specific transport checklist for your own department seems fairly easy but using a 'checklist for checklists' might help to address design and implementation issues which are sometimes unfamiliar for nurses and physicians.

- The Checklist Manifesto
- Projectcheck.org

During inter-hospital transfer, communication between the transport team and referring/receiving specialists may be required to address specific medical details or to ask for additional resources. It is also important that the transfer plan provides for appropriate communication between referring and receiving specialists.

Note

Follow the rules of closed loop communication as in aviation, and have each person repeat his/her task.

Assign specific roles for specific members of the transport team, e.g.: who is responsible for artificial respiration including ventilator settings and positioning of the endotracheal tube. Other necessary tasks such as administration of medication should be assigned to another team member.

Note

Several transports occur in the middle of the night or during weekends. Pre-set roles and rules facilitate the transport at any time and prevent incidents.

A 205 kg patient with suspected bacterial meningitis and decreased level of consciousness is scheduled for a 40-minute helicopter transfer from a local hospital to a university clinic for further diagnostic workup and medical management. As a member of the transport team, what preparations do you make before leaving to take over the patient at the referring hospital?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

- Is the receiving hospital informed and ready to admit the patient; who is the responsible receiving physician?
- What is the clinical status of the patient? (The ABC of ACLS/ATLS may serve as a guide to assess the clinical status.) Is there a need for securing the airway or artificial ventilation? What are the settings on the ventilator, e.g.: PEEP and FiO2, the number and medication of syringe pumps. Do we expect deterioration? Prepare emergency medication.
- Where exactly is the patient expected i.e.: ICU versus CT or MRI suite versus emergency department? Is the team and necessary equipment ready to continue intensive care in that room? – remember weight limits of the CT trolley, number of syringe pumps, etc.
- What are the alternative modes of transfer? e.g.: road ambulance versus helicopter. What are the needs and limits, such as the weight limit of the stretcher, legal requirements for fixation of the patient in a helicopter. Special heavy-duty transport stretchers may be needed (possibly from the fire brigade). Such meticulous planning will take time but may help reduce the actual transport time.

3. 2. Early Versus Late Transfer and the Need for Stabilization

Note

In transporting critically ill patients there is always a delicate balance between speed and safety.

The time needed to stabilize a critically ill patient varies considerably and, occasionally, is not possible. In cases of acute myocardial infarction or cerebral stroke, an ICU patient should be transported as soon as possible to a cardiac catheterization lab or a stroke unit. In other situations, however, several hours may be required to optimize the patient and make proper preparations for ICU transport.

It is important to consider the resources available in terms of personnel and equipment as well as considerations such as distance and even resources during transport. An additional consideration is the need for patient transfer in order to receive time sensitive interventions. For example, it may be reasonable to perform an intrahospital transport of a critically ill patient for cardiac catheterization even though the patient may be unstable. This may be prudent if additional specialist care can continue resuscitation and stabilization en route and in the catheterization lab.

Contrast this case to that of a septic patient with profound hypotension and acute kidney injury with anuria that needs to be transferred several hundred miles to a tertiary care center. This patient will undergo a long out of hospital transfer with limited interventions and staff en route. This patient may benefit from hemodynamic and metabolic optimization prior to transport.

It is also worth mentioning that many cases of patient care which require some form of transportation are not black and white. In other words, in some instances the patient may not need to be 100% “stabilized” prior to transport. It is possible and sometimes preferred to continue stabilization and optimization en route. Moreover, with some surgical emergencies may not be practical or possible to “stabilize” a patient prior to transport; for example, necrotizing skin infections in need of debridement or abdominal compartment syndrome in need of decompressive laparotomy. Stabilization may only be possible after source control or definitive surgical management.

In some instances, retrieval teams include experienced intensive care medicine retrieval physicians that can not only assist in stabilization at the sending facility but can very appropriately continue management of oxygenation, ventilation, hemodynamic, and other metabolic abnormalities during transport. In fact, in Europe and Australia teams that have retrieval physicians is very common. Furthermore, in some special circumstances teams may be able to bring the definitive care to the patient. Some ECMO retrieval teams may be able to cannulate and stabilize a patient at the referring facility. Likewise, some very specialized military medical teams bring a fully functional surgical capability to the point of injury or forward operating base medical center.

(Wilcox et al. 2022) recently published a review of advances in transport of critically ill patients. In it they recommend a number of key pre-transport interventions to consider that optimize a patient for a safe and timely transport. Their recommendations are summarized in the following figure (Figure 1):

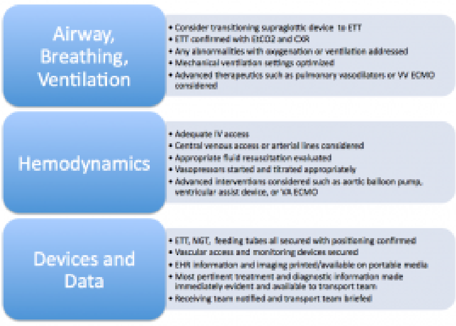

Figure 1: Reccomendations in pre-transport interventions. Wilcox, et al. 2022

Think

Apart from a paramedic and/or an emergency physician, other personnel may be of help during transport such as a midwife, pediatrician, or extracorporeal circulation technician. Do you know how to contact these personnel in your institution and how much advance notice they need?

Challenge

Recognize which urgent treatments required by some critically ill patients are unavailable in your hospital, thus necessitating a transfer. Create a list of indications for immediate transfer.

Trauma patients, for instance, need to be referred to a trauma center. For more about triage and the management and transportation of severe trauma patients look at the following flash conference:

- Mathieu Raux. Critical Care Refresher Course Trauma. Transportation of severe trauma. Barcelona 2010

Note

The goal in transporting critically ill patients is to continue current ICU treatment as safely as possible and to provide additional treatment if necessary.

In Text References

(Grines et al. 1998; Silbergleit et al. 2003; Cantor et al. 2009; Malpass et al. 2015; Lowe and Trautwein. 2007; Broman and Frenckner. 2016; Bryner et al. 2014; Gilbey et al. 2020; Froehlich et al. 2018)

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3. 3. The Transfer Team

Providing critical care support within limited space and under difficult circumstances is considerably different from performing the same task in a hospital-based ICU. It requires – besides the usual professional skills – transfer experience. Randomized, controlled, prospective clinical trials addressing the transport of critically ill patients are challenging to conduct and, therefore, lacking. This is especially true when it comes to the analysis of crew composition. However, there is some evidence that specialized transport teams provide better care, with decreased morbidity during and after transfer. Guidelines regarding the requirements for the transfer of an individual ICU patient, in terms of the competencies, specialty, grade and experience of the medical escort, are non-specific but the quality of the escorting personnel and the resources/equipment available to them are the most important determinants of the 'transportability' of a critically ill patient.

For inter-hospital (ambulance and air medical) transport, additional training is required for any provider to be able to adequately provide critical care support outside the ICU. The level of training of emergency medical technicians, registered critical care nurses, or employees of commercial air medical companies differs considerably between countries. Furthermore, staffing varies tremendously from country to country and region to region. For example, it is very common to have specialty-trained physician as part of critical care transport teams in Europe and Australia. Although less common in North America, this team configuration seems to be slowly growing in popularity. In comparison, critical care transport in the United States (air medical transport in particular) is largely conducted by teams of nurses and paramedics with additional training. The data regarding clinical outcomes based on staffing are not robust, often conflicting, and inconclusive.

Regardless of team composition, it is recognized that continuing specialized transport education, quality audits, and regular professional experience in both hospital-based and transportation critical care are essential.

In Text References

(Gray, Bush and Whiteley. 2004; Droogh et al. 2015; Stroud et al. 2013; Alabdali et al. 2017; King et al. 2007; van Lieshout et al. 2016; Whiteley, Macartney and Mark 2011; Dorlac et al. 2009; Renz et al. 2012; Read et al. 2020; Belway et al. 2006; Popal et al. 2019; Gunnarsson et al. 2017)

3. 3. 1. Transportation Team Clinical Guidelines, Protocols, and Oversight

It is important to understand and consider the limitations of what different transportations are capable of and are trained to do. Most teams have developed approved and reviewed guidelines for how to manage different pathologies as well as interventions they can or cannot perform. This is often dependent on crew composition and training. For example, a team with specialist retrieval physicians may have very few limitations with regard to therapeutic interventions. On the other hand, a team that is composed of a flight paramedic and flight nurse might have very strict limits on interventions they can perform, doses of drugs they can administer, or mechanical ventilation parameters.

Different agencies may also have standard operating protocols for how they transport patients. Some agencies may switch over to different drugs. In some cases, teams will switch certain pieces of equipment such as transition from wet or dry chest tube suction drainage devices to simple Heimlich valves to save significant space, remove long excess tubing, and generally facilitate simpler transport. Finally, there may be certain logistical limitations based on the transport vehicle; a team may have limitations on patient weight or girth based on the aircraft they fly.

It is important for transferring physicians to understand these limitations. This has implications for which transportation team should be called. If only a single organization provides transport, and special equipment or unique circumstances exist, it may be prudent to contact the organization prior to transport and discuss specific patient needs or other parameters that may be outside of their usual operating parameters.

For transport programs that staff exclusively with paramedics, nurses, or other health professions physician engagement is paramount. Physician medical directors serve important roles as medical directors, clinical subject matter experts, quality improvement champions, and patient advocates. In general, their key responsibilities include clinical guidelines development, education, competency evaluation, credentialing, and clinical quality assurance. Because of the depth and breadth of clinical work involved in transport, it may be beneficial to have a multidisciplinary medical direction team from various specialties such as emergency medicine, critical care medicine, trauma and acute care surgery, anesthesia, obstetrics, pediatrics, and neonatology.

Programs that regularly staff transport vehicles with physicians do not necessarily need a medical director for sake of legal or delegation of clinical privileges, but will likely benefit from a physician-driven medical leadership team that provides many of the aforementioned capabilities. Furthermore, while physician staffed programs do not necessarily need strict “protocols” because of their training and clinical experience, developing and implementation of standardized clinical approaches to different pathologies and standard operational procedures for transportation procedures is generally prudent.

In Text References

(Warren et al. 2004; Kiss, Bölke and Spieth. 2017; No authors 2016; Stewart. 1987; Institute Of. 2006; Aspiotes et al. 2018; Reichheld et al. 2021; Commission on Accreditation of Medical Transport 2018; Wilcox et al. 2022)

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3. 4. Transport Equipment

The equipment used to transport patients is highly specialized to provide mobile critical care support to patients. While in many parts of the world the equipment is generally similar (e.g.: mechanical ventilators, medication pumps, etc.) there is tremendous variation in terms of individual service capabilities. It is important to understand your local resources and the equipment teams can provide.

3. 4. 1. Trollies

Figure 2: Example of HEMS-stretcher for inter-hospital transport.

Figure 3: Example of custom-made intra-hospital trolleys for intensive care or anesthesia transport.

In order to safely continue ICU treatment during transport, mobile ICU equipment is mandatory. This equipment may be mounted on a dedicated ICU transfer trolley, which is mechanically coupled with the ICU bed in the case of intra-hospital transfer. This coupling is often custom-made and should have a firm mechanical mounting and quick release mechanism. Careful design of such a tailor-made trolley requires knowledge of the dimensions of essential elevators in the hospital and even those to remote locations. Mounting of equipment for use in ground or air ambulances may have to satisfy the special requirements of the relevant transport authorities. These mounts have to endure high forces in case of an accident. So, it is not advisable just to put some equipment on a normal stretcher for transport. There are several options for mounting the transfer-equipment on the stretcher so that continuous treatment can be guaranteed.

Newer transport equipment may be suitable even for MRI suites so that changing equipment is not necessary.

Figure 4: Examples of an inter-hospital Mobile ICU trolley in combination with a dedicated Mobile ICU.

Note

Every change in monitoring or equipment poses a risk for the patient.

Anecdote

A young woman with twin pregnancy in labor was successfully transferred to a university hospital. Contractions were diminished using tocolytic drugs. During handover of the tocolytic medication, the syringe was removed from the pump without closing the 3-way stop cock. The patient received a bolus of beta-stimulants and developed severe tachycardia leading to emergency cesarean section.

3. 4. 2. Equipment for Monitoring and Physiological Support

All ICU equipment considered essential for monitoring and treating the critically ill patient should be used during transfer. For IFT one usually has to change to a transport-ventilator. Modern transport ventilators are battery-powered, robust, often fitted with a turbine and need just oxygen, pressurized gas can often be omitted. It is possible with these tools to continue the ventilation settings from the ICU ventilator (e.g.: PC-CMV or APRV). For IHT it is possible to switch to a transport ventilator, but modern ICU equipment, such as high specification ventilators, is often suitable for use during transfer, with internal batteries for stand-alone use and options for data storage. It should be robust and firmly attached to the patient trolley to limit the risk of disconnection, dislodgement/damage or causing injury to patient/staff.

Transport vehicles, however, are limited in space and, particularly with aircraft, weight. Therefore, it is beneficial for many of these devices to be smaller and more compact. Any monitoring device or piece of equipment needs to be carefully secured for patient and transport team safety. Furthermore, in the setting of air medical transport, any device should pass appropriate airworthiness testing by the appropriate regulatory body, ensuring that it can safely operate within its expected parameters without interfering with communication equipment, navigation, or other avionics. Finally, equipment must be available to store supplies that are sensitive to environmental temperature changes. This might include coolers for blood products or secure, temperature-controlled storage spaces for medications.

In Text References

(Warren et al. 2004; United States 2016; United States Department of the Air 2019)

3. 4. 3. What to Monitor

- Continuous monitoring of heart rate and rhythm using three-lead (or more) ECG
- Ability to acquire, continuously monitor, print and even transmit 12 lead ECG
- Preferably the ability to measure multiple invasive blood pressures, but at a minimum the ability to regularly monitor non-invasive blood pressures
- Respiratory rate and oxygen saturation
- Quantitative waveform end-tidal capnography (mandatory in every ventilated patient)
- Temperature
- Intermittent or continuous fetal heart rate monitoring and tocometry (if applicable and possible)

Note

During transfer of mechanically ventilated patients with serious head injury, monitoring end-tidal capnography is crucial to prevent hyper- and hypocapnia with possible cerebral vasodilation or vasoconstriction and consequent changes in intracranial pressure or ischemia. Increased mortality has been reported after severe hypocapnia ($PaCO_2$ <3.5 kPa or 27 mmHg). Nevertheless, there may be a difference between end tidal and arterial PCO_2, so there may be a consideration of transportable ABG machines.

Note

End-tidal CO_2 ($PetCO_2$) at 20 minutes post intubation has been shown to be predictive of mortality in ventilated blunt trauma patients. Only 5% of patients with $PetCO_2$ < 3.25 kPa (24 mmHg) survived to discharge – another reason for using end-tidal capnography to monitor and guide management of trauma patients during transport.

Inadvertent hypoventilation with hypercapnia in a patient with pulmonary artery hypertension may lead to acute right heart failure, especially soon after cardiac surgery. Invasive blood pressure monitoring (ideally with a pulmonary arterial catheter) and capnography with close alarm limits are important to a successful transport from the operating room to the ICU.

3. 4. 4. Defibrillator/Pacer

Today's advanced automatic external defibrillator/pacemaker no longer requires a bulky screen and paddles and is easy to store. Attention should be paid to ensure disposable pads, with the appropriate connections, are replenished after use. Preferably, the defibrillator should be incorporated into the monitoring platform to limit space and weight as well as quick and immediate access to shock delivery.

3. 4. 5. Transport Ventilators

Transport ventilators should be able to meet the needs of complex ICU respiratory patients. In some circumstances it may be practical to simply transport the patient on their ICU ventilator. Occasionally this is possible (often by ground) when the vehicle has the ability to provide the appropriate continuous electrical power and compressed gases needed.

Otherwise, transport ventilators should be able to provide the same degree of mechanical ventilatory support. They should be able to provide both pressure and volume control modes of ventilation. They should have multiple adjustable parameters beyond simply the rate, tidal volume, concentration of oxygen, and PEEP such as inspiratory:expiratory ratio, inspiratory flow rate, ramp, flow or pressure trigger sensitivity and more. The transport ventilator should be able to monitor and provide important data points to clinicians such as exhaled tidal volume, measure minute ventilation, peak pressure, and plateau pressure. Ideally, the ventilator should be able to provide dynamic visual indicators of ventilatory function such as pressure, flow, and volume waveforms. Finally, both sending physicians and transport teams need to be aware of the transport ventilator limitations in the setting of important patient pathology. For example, some ventilators cannot deliver the high inspiratory flow rates that some patients may need, such as in the setting of severe ARDS.

It is also beneficial if the transport ventilator can perform non-invasive ventilatory support so as to limit the need for additional equipment. This should ideally include continuous positive airway pressure (CPAP), bilevel positive airway pressure (BPAP), and high flow nasal cannula (HFNC).

How could you find out before transport whether your portable mechanical ventilator is suitable for use during transport of patients with severe respiratory insufficiency?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

In many portable ventilators the airway pressure is dependent on the pressure of the oxygen cylinders. When this pressure is insufficient to deliver the necessary Pmax and/or PEEP, hypoventilation or desaturation may occur in patients with severe respiratory insufficiency. Before transfer of the patient on the MICU trolley, a short period on the portable ventilator (10–15 mins) should prove its suitability (trial period).

Benchmark reports are currently available for transport ventilators. These may be of assistance when deciding which machine to purchase. Mobile ventilators are robust and reliable, but they are dependent on an oxygen gas supply and on power. It is mandatory to have a self-expanding ventilation bag next to the ventilator in case of problems with the machine!

According to the transferred patient population you may need some adjuncts to the transport ventilator, e.g.: the delivery of inhaled nitric oxide.

3. 4. 6. Medical Air and Oxygen Supply

The number of oxygen bottles that must be transported to ensure an adequate supply is dependent on the duration of transfer and the size/capacity of the cylinders. Ensure all cylinders are full before transport. Hoses and adapters for the supply must be compatible in the facility, ambulance and aircraft (wall connections reduce the number of cylinders that can be transported). Cylinders are indispensable for transit in elevators and corridors. Ground and air ambulances may have pressurized oxygen and air.

The hoses and plugs for oxygen and pressurized air on transport trolleys are more prone to wear and tear than equivalent stationary fittings in the ICU. Therefore, annual maintenance and premature replacement of vulnerable parts should be integrated in the safety management system of your intra- and inter-hospital transport system.

Consideration of oxygen supply is particularly important under certain circumstances. Mechanical ventilation, and especially non-invasive ventilation (CPAP, BPAP, and HFNC) consume very high volumes of oxygen. While for shorter transports of 10-20 minutes this may not be an issue, for longer fixed wing transports of 1-2+ hours the supply should be carefully considered. The time any given tank can supply a given oxygen flow can be calculated if the size of the tank, pressure of the tank, and oxygen flow rate are known. First, it is worth mentioning that patients requiring very high oxygen requirements (for example, HFNC at 60 L/min and 100% oxygen) should be carefully evaluated to determine if their clinical course is likely to deteriorate and intubation at the sending facility would be prudent. These considerations should be cautiously weighed against the risks of intubation. This may be safer for the patient and solve the logistical challenge of oxygen consumption. Next, if the decision is made to proceed with a high-consumption mode of oxygen therapy, the oxygen available on the transport vehicle should be carefully calculated with a generous safety buffer. Alternate and contingency plans should be considered in the event there are technical difficulties with oxygen delivery, transport is delayed, or oxygen demand is greater than initially calculated.

How do you calculate the time a cylinder with pressurized oxygen will last?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

The barometer of the cylinder displays the pressure e.g., 200 bars (200 times the normal ambient pressure). For a five-liter cylinder, the amount of oxygen available will be 5L x 200 = 1000L. If the patient is ventilated with 15 L/min and FiO_2 of 50%, 7.5 L O_2/min will be needed. The time for the cylinder to empty is 1000L / 7.5 L/min = 133 min. With many portable ventilators you will also need additional pressurized air.

It is always prudent to have a spare cylinder in range, in the event there is any problem with the oxygen supply or if the oxygen supply runs low due to an unanticipated problem.

3. 4. 7. Medication Pumps

As more drugs are available with a very short duration of action and better titratability, syringe pumps are increasingly being used for administration of sedatives, analgesics and vasopressor support.

Before any transport, the staff should check:

- If enough spare syringes or medication bags are available to cover the patient's needs during transport. For critical, life-sustaining medications, like vasopressor or inotropes, extra medication should be taken or supplies to quickly mix medication drips should be immediately available
- For special and adequate tubing, depending on the type of pump
- Longer tubes facilitate the loading into an ambulance or aircraft
- For battery power and number of wall sockets available in the ambulance or at the receiving site
- Which medications are indispensable, and which may be interrupted temporarily

> **Note**
>
> Different hospitals may use different modes of calculating and applying medication in syringe pumps, e.g.: mcg/kg/min, mcg/min, mg/hour, ml/hour, or even number of drops/minute in infusion pumps. In addition, the concentration of medication in the pumps may differ from one ICU to another or even within a hospital. All medications should be labelled with the drug name, concentration, and infusion rate.

The above may lead to adverse events during changing of pumps. Transporters should be aware of the differences in concentration. It is prudent to have two team members cross check the drug information to ensure safe delivery of medication. If in doubt, they should draw new syringes with the concentration they are used to, rather than taking over some unusual concentration at the referring hospital. The correct dosage should be communicated at the receiving unit. For respective transport teams, it is wise to develop a standard formulary so that all team members mix different medication drips uniformly.

> **Note**
>
> In many helicopters the ceiling is not high enough to guarantee a sufficient spontaneous flow from gravity for IV fluids. Thus, pressure bags or additional infusion pumps may be needed for every infusion. Glass bottles should be replaced by non-breakable plastic containers which allow the application of external pressure. Beware of the risk of air embolism in any intravenous line in a pressure bag.

3. 4. 8. Suction equipment

For critical care purposes, machines should be capable of suctioning fluid at a rate of at least 25 L/min. If the unit is used for suction on a pleural drain, another unit should be available for other indications, e.g.: suction of tracheal or oral secretions.

3. 4. 9. Ultrasound

The rise of ultrasound and ubiquity of ultrasound, as well as advances in ultrasound technology, have facilitated the delivery of point of care ultrasound (POCUS) by transport teams. While there is no definitive evidence that the implementation of ultrasound by transport teams improves outcomes, there is certainly data supporting its safety and feasibility. Furthermore, in some circumstances that mimic situations where ultrasound has otherwise been evaluated in-hospital (e.g.: bedside echocardiography performed at the sending hospital) it is reasonable to extrapolate from these studies. Additionally, many non-physician transport team members are currently being trained to acquire and interpret ultrasound images.

Perhaps the greatest utility of ultrasound is implementation to address important clinical questions that may result in changes of management (differentiating potential causes of shock), changes in destination (identification of specific pathology that would need to be addressed by a specialist at a different receiving facility), or to enhance efficiency, accuracy, or safety of certain procedures.

3. 4. 10. Mobile Point-of-Care Laboratory Devices

Laboratory diagnostic tests are a cornerstone of diagnosis and treatment in critical care. Advancing technology has allowed some of these assays to be provided at the point of care in the hospital and the transport environment. Many teams carry devices such as the epoc® Blood Analysis System (Siemens Medical Solutions USA, Inc.) or the i-STAT 1® (Abott). These devices have limitations including cost, temperature sensitivity, and the need for regular calibration. However, they can be of use to transport teams.

Individual cartridges associated with these devices can provide information on electrolytes, blood gases, hemoglobin, and even cardiac enzymes with reasonable accuracy (assuming they are maintained appropriately and calibrated in accordance with the manufacturer's standard). They are perhaps most useful when trending values over the course of a long transport. There are some data that have suggested they are useful and can sometimes drive important changes in clinical care such as ventilator changes, critical electrolyte replacement, ECMO settings, and more.

3. 4. 11. Mechanical Circulatory Support

Mechanical circulatory support devices (MCSD) are devices that are designed to support cardiac function in the setting of cardiogenic shock due to myriad causes. MCSD include devices such as intra-aortic balloon pumps (IABPs), left ventricular assist devices (LVADs), and extracorporeal life support (ECLS). These devices are commonly transported as patients initiated on these therapies at some facilities require specialized interventions (transplant, CABG, or other cardiothoracic procedures) at other tertiary or quaternary hospitals. These specialized devices require critical care transport services due to the nature of the device itself as well as the generalized patient care needed.

The logistics of loading and safety securing the devices can be challenging. The devices themselves take up significant space and weight. Many of them also have specific needs in terms of power supply, gas supply, and other important logistic needs.

These devices require special training and knowledge to operate. Crews must understand the device function, logistics of moving someone on the device, as well as troubleshooting problems that may arise. Crew composition to transfer these devices varies from country to country, and even within regions of a country.

3. 4. 12. Inhaled Pulmonary Vasodilators

Another therapeutic intervention that, until recently, was limited to the in-hospital setting is initiation of pulmonary vasodilators. These inhaled medications, such as nitric oxide and inhaled prostaglandins (e.g.: epoprostenol) have been used in the adult, and more prominently, pediatric and neonatal ICUs for several indications. With the advent of more advanced ventilators and medication delivery devices, these medications can be delivered in line with the ventilator circuit using compact administration devices.

Although some teams have been using these medications for some time, the recent rise of popularity and use of these medications occurred during the COVID-19 pandemic. While no convincing evidence exists in the world of adult critical care that inhaled pulmonary vasodilators improve patient-centered outcomes in the setting of COVID-19 pneumonia, these medications were used successfully to stabilize and safely move patients to large tertiary or quaternary care centers for definitive management.

3. 4. 13. Additional Emergency Medical Equipment

In the transport environment, with limited space, weight restrictions, and working outside the hospital with limited equipment, how you carry items is as important as what you carry. Instead of having large bags filled with various pieces of medical equipment, it is a good idea to have the equipment organized in such a way that it decreases cognitive load of searching for and collecting all the equipment needed for emergency procedures.

Many critical care teams have compact airway kits. Some of them are very ergonomic, color coded, and structured in such a way that all required equipment is immediately available for airway management. Equipment for other emergency procedures such as hemorrhage control, finger or tube thoracostomy, pericardiocentesis, or vascular access can be organized similarly. The same is true for medications: Rapid Sequence Intubation (RSI) medications, cardiac resuscitation medications, or obstetric emergency medications can be color coded and organized for easy recognition and access.

Figure 5: Examples of a prehospital team emergency airway kit called the SCRAM™ (Structured Critical Airway Management) System.

Figure 6: Examples of a prehospital team emergency airway kit called the SCRAM™ (Structured Critical Airway Management) System.

Finally, kits can be organized for other forms of specialty transport as well; for example, special kits and bags are designed for ECMO transport with an assortment of emergency equipment and even a backup ECMO circuit. Commonly, pediatric and neonatal transport teams will have bags specially designed and organized with appropriately sized equipment for the different age groups they serve.

Warning

A final check of the emergency case is mandatory before you leave a relatively safe environment such as the emergency department or ICU. Be sure to check batteries, cylinders and expiration dates.

3. 4. 14. Future Directions and Considerations

Some of the equipment outlined in this section was not available a decade ago. Many of the limitations of transport, as previously mentioned, are space and weight. As technology evolves and equipment, from ventilators to point-of-care blood analyzers, advances it is our hope that even more robust critical care capabilities can be delivered to the bedside and continued enroute to destination facilities by transport teams.

What should you ask yourself when deciding whether to use additional (non-essential) equipment during transport?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

• How useful to patient care during the transport is the device?
• What are the risks for the patient if the device is displaced unintentionally (e.g.: blood loss)?
• What is the battery capacity and what are the risks to the patient if the device shuts down?
• Is it safer to uncouple the device during transport because the risks outweigh the benefits?
• Does the weight, size, possibility of firm attachment to an ambulance or legal restrictions preclude the use of a device, especially in aeromedical transport?

Challenge

Find out the technical limitations of equipment used during transport outside the ICU. What are the weight limits or patient size limits for stretchers being transported by ambulance or helicopter, and for CT or MRI patient trolleys? What are the maximum limits of the transport ventilator (peak inspiratory pressure, PEEP, minute ventilation)? Check the electrical current in your transport vehicle: is a 220 Volt AC current available, and how many sockets are installed? What is the maximum ampere limit of the electrical fuse and battery capacity of your equipment? Do you have replacement batteries? Find out what kind of equipment you may use during transfer, and which medical monitoring devices may interfere with the electronic equipment of your ambulance/air ambulance. Which specialized interventions can be performed in your ambulance (defibrillation in a helicopter, intra-aortic balloon counter pulsation in an ambulance, extracorporeal cardiac and respiratory devices)?

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4. Conclusion

Transport of critically ill or injured patients is often required to get patients the appropriate care they need. The decision to move a patient between or within a facility is not benign. Physicians must carefully weigh the risks and benefits of patient transport, as well as ethical considerations. If the decision to transport the patient is made, it is incumbent on the sending physician to understand the capabilities and scope of practice of the team performing the transport. Finally, transport equipment is highly specialized and it is important to ensure that the transporting agency brings everything necessary to safely complete the transfer.