A STUDY OF ADVERSE EVENTS OF INTRA-HOSPITAL TRANSPORTATION OF CRITICALLY ILL PATIENTS FROM THE EMERGENCY DEPARTMENT, HOSPITAL UNIVERSITI SAINS MALAYSIA

by

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**Dissertation Submitted In
Partial Fulfillment Of The
Requirement For The Degree Of
Master of Medicine
(Emergency Medicine)**

**UNIVERSITI SAINS MALAYSIA
NOVEMBER 2006**

ACKNOWLEDGEMENTS

I am truly indebted to everyone who has helped me in this study. I would like to take this opportunity to thank the following persons, who has dedicated their time and energy in giving me assistance, guidance, advice and comments right from the beginning until the completion of my dissertation:

Dr. Rashidi bin Ahmad, Lecturer and Acting Head of Department, Department of Accident and Emergency, Hospital Universiti Sains Malaysia who is the supervisor for this dissertation.

Dr. Mohd. Idzwan bin Zakaria, Lecturer and Emergency Physician, Department of Accident and Emergency, Hospital Universiti Sains Malaysia, co-supervisor who has relentlessly guiding and motivating me throughout till completion of this dissertation.

All my lecturers, specialists, my fellow colleagues and staff of Emergency Department at Hospital Universiti Sains Malaysia and Hospital Kuala Lumpur.

Special thanks to my colleagues in Department of Public Health, School of Medical Sciences Universiti Sains Malaysia who have helped me in churning the statistical data and making it meaningful.

My parents, the late Hassan bin Din and Zakiah Malek and my parents in-law, Idros bin Kassim and Aminah binti Daud for their love, understanding and valuable supports.

Most importantly my dearest wife Dr. Zainanda binti Zainal and my children Harith Daniel, Iliya Hanis and Alisa Najah for their understanding, support, encouragement, patience and love throughout my postgraduate studies and during my dissertation preparation.

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LIST OF ABBREVIATIONS

ACLS	Advance Cardiac Life Support
ATLS	Advance Trauma Life Support
ATT	Health Attendant
BLS	Basic Life Support
CBD	Continuous Bladder Drainage
CCU	Cardiac Care Unit
CT	Computed Tomography
CVP	Central venous pressure
DR	Medical Officer
ECG	Electrocardiogram
ED	Emergency Department
ETT	Endotracheal tube
HDW	High Dependency Ward
HR	Heart Rate
HUSM	Hospital Universiti Sains Malaysia
ICL	Invasive Cardiac Laboratory
ICP	Intracranial pressure
ICU	Intensive Care Unit
IV	Intravenous
MA	Medical Assistant

MI	Myocardial Infarct
MTLS	Malaysia Trauma Life Support
NeuroICU	Neuroscience Intensive Care Unit
NIBP	Non-Invasive Blood Pressure
OT	Operating Theater
RR	Respiratory Rate
TISS	Therapeutic Intervention Scoring System
SN	Staff Nurse

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ABSTRAK

KAJIAN PEMERHATIAN TERHADAP KEMUDARATAN PEMINDAHAN INTRAHOSPITAL PESAKIT KRITIKAL DI JABATAN KECEMASAN, HOSPITAL UNIVERSITI SAINS MALAYSIA

PENGENALAN

Proses pengangkutan atau pemindahan pesakit yang kritikal adalah satu perkara yang boleh mendatangkan risiko terhadap pesakit dan adakalanya boleh mendatangkan risiko kepada personal yang terlibat secara langsung dalam proses tersebut. Dalam satu kenyataan, pesakit kritikal yang dibawa keluar dari unit rawatan rapi untuk tujuan diagnostik dianggap tidak berada di dalam zon rawatan sempurna sebaliknya dianggap berada di luar kawasan rawatan yang ideal. Proses permindahan pesakit kritikal bertujuan untuk memberikan pesakit peluang dalam mendapatkan rawatan yang lebih eksklusif dengan bantuan peralatan yang canggih dan kepakaran yang lebih khusus. Kajian ini dibuat dengan harapan dapat memperkenalkan HUSM kepada gejala gejala yang timbul semasa proses pengangkutan pesakit kritikal dan seterusnya menyediakan satu rangka kerja yang sesuai untuk menanganinya pada masa hadapan. Objektif kajian ini adalah:

1. Untuk menentukan kelemahan yang timbul semasa proses pemindahan pesakit kritikal dari jabatan perubatan kecemasan Hospital Universiti Sains Malaysia.
2. Untuk menentukan bentuk rawatan yang diperlukan oleh pesakit kritikal tersebut semasa proses pemindahan dijalankan.

3. Untuk menentukan faktor-faktor yang menyumbang ke arah wujudnya kelemahan kelemahan semasa proses pemindahan dan bentuk rawatan yang diberikan terhadap pesakit kritikal.

KEPUTUSAN:

Sebanyak 257 pemindahan intra-hospital melibatkan seramai 247 pesakit kritikal yang memenuhi syarat kelayakan telah dilakukan dalam dua belas bulan tempoh kajian.

Hasil kajian mendapati :

1. Tidak timbul sebarang kelemahan di dalam 157 pemindahan pesakit (61.5%±0.48). Terdapat pertalian ketara yang melibatkan perubahan fisiologi di dalam 100 pemindahan pesakit (38.9%±0.48). Dari 100 pemindahan ini, 68(26.5%) hanya mengalami perubahan di dalam bentuk fisiologikal, 15(5.8%) mengalami kedua-dua perubahan fisiologikal dan kelemahan dari aspek peralatan, dan manakala 15(5.9%) telah memerlukan sekurang-kurangnya satu perawatan utama. Sekurang-kurangnya 18 pemindahan pesakit telah melibatkan kewujudan kelemahan yang berkait dengan peralatan (7.0%). Sekurang-kurangnya satu keperluan terhadap perawatan major dalam 15 pemindahan pesakit (5.9%).
2. Dilaporkan tiada kes kematian semasa proses pemindahan dilakukan. Keperluan terhadap prosidur major adalah 9.3% di kalangan pesakit yang memerlukan bantuan pernafasan mekanikal berbanding dengan mereka yang bernafas secara normal (3.4%).

3. Penganalisaan Simple logistic regression membuktikan hanya pretransport Therapeutic Intervention Scoring System sahaja yang berkait rapat dengan kewujudan kelemahan fisiologikal dan keperluan terhadap perawatan major. Umur dan jantina pesakit, bilangan personal yang terlibat dalam proses pemindahan dan destinasi perpindahan tidak mempunyai kaitan terhadap kadar kejadian kelemahan proses pemindahan pesakit.

KESIMPULAN

Hasil kajian mendapati, sebahagian besar pesakit kritikal yang telah melalui proses pemindahan dari jabatan perubatan kecemasan telah mengalami perubahan fisiologikal yang serius.

Sebahagian daripada petunjuk-petunjuk klinikal seperti tekanan darah, bilangan nadi, kadar pernafasan dan kadar kandungan oksigen dalam darah terbukti menjadi petunjuk yang berkesan di dalam kewujudan kelemahan semasa proses pemindahan pesakit kritikal.

Tahap ketenatan penyakit seperti yang ditunjukkan oleh Therapeutic Intervention Scoring System (TISS) mempunyai pertalian rapat dalam menentukan kewujudan kelemahan fisiologikal dan terhadap keperluan kepada perawatan major.

Bilangan dan peranan setiap anggota yang terbabit dalam proses pemindahan pesakit kritikal dan jenis peralatan yang perlu dibawa bersama mestilah bersesuaian dengan indek ketenatan penyakit seperti yang ditunjukkan oleh pre-transport TISS.

ABSTRACT

A STUDY OF ADVERSE EVENTS OF INTRA-HOSPITAL TRANSPORTATION OF CRITICALLY ILL PATIENTS FROM THE EMERGENCY DEPARTMENT, HOSPITAL UNIVERSITI SAINS MALAYSIA

INTRODUCTION

The transports of critically ill patients always involve some degree of risks to the patient and sometimes to the accompanying personnel. It has been stated that when a patient is transported from an ICU to a diagnostic area such as a radiology suite, they are not in a hospital, but only close to one. Intrahospital transport refers to transportation of patients within the hospital for a purpose of undergoing diagnostic or therapeutic procedures, or transfer to a specialised unit. The basic reason for moving a critically ill patient is the need for additional care, either technology and/or specialists not available at the patient's current location. The objectives of this study are:

1. To determine the prevalence of adverse events during transfer of critically ill patients from emergency department to other specialised unit in HUSM.
2. To determine the prevalence for the requirement of therapeutic interventions during transport.
3. To determine the factors predicting the occurrences of adverse events and the requirement for major therapeutic intervention during the intrahospital transport.

RESULTS

A total of 257 transportations involving 247 critically-ill patients fulfilling the inclusion and exclusion criteria arrived to emergency department were included in this study over the period of twelve months. From this study, it was found out that:

1. There were no adverse events in 157 transports (61.5% ± 0.48). There was a significant in at least one variable in 100 transports (38.9% ± 0.48%). Of these 100 transports, 68 (26.5%) had derangement in only the physiologic variables, 15 (5.8%) had both a physiologic derangement and an equipment-related event, and 15 (5.9%) required at least one major intervention. At least one equipment-related adverse event occurred in 18 transports (7.0%). At least one major therapeutic intervention was performed in 15 transports (5.9%).
2. There was no arrest or death during transport. The requirement for a major procedure was 9.3% in mechanically ventilated patients versus 3.4% in non-ventilated patients.
3. Simple logistic regression analysis showed only pretransport Therapeutic Intervention Scoring System was significantly associated with the development of physiologic deterioration and the requirement for major intervention. The age and sex of the patient, and the number of escort personnel accompanying the transport did not affect the frequency of adverse event.

CONCLUSION

From this study, majority of the critically ill patients transported from the Emergency Department developed serious physiologic adverse events during intrahospital transport.

Some of the clinical predictors such as blood pressure, heart rate, respiratory rate and oxygen saturation by pulse oxymeter were shown to be a significant indicator in the development of adverse events during transport of critically ill patients.

Severity of illness as shown by Therapeutic Intervention Scoring System (TISS) is significantly associated with the physiological occurrence of adverse event and major interventions. The team composition and equipment required on transport must be commensurate with the pretransport severity of illness.

1. INTRODUCTION

Critically ill patients are defined as those patients who are at high risk for actual or potential life-threatening health problems. The more critically ill the patient is, the more likely he or she is to be highly vulnerable, unstable and complex, thereby requiring intense and vigilant nursing care. The approach required in managing the critically ill patient differs from that required in less severely ill patients with immediate resuscitation and stabilization of the patient's condition taking precedence. Priorities are:

- prompt resuscitation, adhering to advanced life support guidelines and the principles of cardiorespiratory management explained in this chapter
- Urgent treatment of life-threatening emergencies such as hypotension, hypoxaemia, hyperkalaemia, hypoglycaemia and dysrhythmias
- Analysis of the deranged physiology
- establishing the complete diagnosis in stages as further history and the results of investigations become available
- Careful monitoring of the patient's condition and response to treatment

Critically-ill patients can be found throughout the hospital, in post-operative recovery areas, coronary care units, the acute medical and surgical wards and accident and emergency (A&E) departments. Recently, there is a new for call as 'ICU outreach'. The purpose of 'outreach' is to achieve earlier identification of these patients so that assessment and, if appropriate, transfer to ICU/HDU is arranged before deterioration occurs to the point of imminent or actual cardiorespiratory arrest. Prompt identification and treatment may even avert the need for admission to ICU/HDU. Many hospitals are now setting up medical emergency teams or 'outreach'/'patient at risk' teams (PARTs). In some hospitals the medical emergency team may be the cardiac arrest team but with a wider remit, while in others this service is provided by the ICU or HDU team.

The transports of critically ill patients always involve some degree of risks to the patient and sometimes to the accompanying personnel. It has been stated that when a patient is transport from an ICU to a diagnostic area such as a radiology suite, they are not in a hospital, but only close to one. Such an indictment implies that patients do not receive the same level of care during the transport and in the diagnostic or procedure area as they receive in the ICU. Therefore the decision to transport must be based on assessment of the potential benefits of transport weighed against the potential risks. The basic reason for moving a critically ill patient is the need for additional care, either technology and/or specialists, not available at the patient's current location.

Intrahospital transport refers to transportation of patients for a purpose of undergoing diagnostic or therapeutic procedures or transfer to a specialized unit. In the context of this study, this specifically involves movement of critically ill patient from emergency department to intensive care areas of the hospital (including intensive care unit, operating theatres, a hospital radiology department and high dependency unit).

Equipment and staffing used for intrahospital transport varies by hospital, clinical services and patient acuity. Intrafacility transfer of the critically ill or injured patient can be anticipated at least once during the patient's course of care in the emergency department, i.e., transfer to an inpatient bed. Patients also may be transported to the laboratory or radiology department for diagnostic or therapeutic interventions. Appropriate staff and equipment must be available to ensure safe transport of the critically ill or injured patient to prevent harm. The same level of knowledge, skills, judgment and technological expertise of the licensed professional nurse that was available within the emergency department should be required for the intrafacility transfer. Staffing patterns should include a licensed professional nurse and ancillary staff support, as needed to provide specialty care during the transfer.

Data from previous studies have supported the association of complications and physiologic deterioration with transport, but none has firmly established the causal relationship with regard to these. Data are even sparser regarding the value to patient management of studies performed which required patient transport. One series reports that only 24 percent of diagnostic studies performed on patients transported from an ICU resulted in therapeutic change within 48 hours (Indeck M, 1988).

Risk to the patient during transport can be minimised through careful planning, used of appropriate qualified personnel and selection of appropriate equipment. Ideally, all critical care transports should be performed by a dedicated, specially trained transport team, but it is recognised that this goal is not always feasible. The decision to transport a patient should be arrived at through the summation of the risks, benefits, and availability of alternatives. As with all procedures, the safest transport is one that does not take at all. Personnel accompanying the patient during transport must be capable of initiating a response to deterioration in the patient's condition in the same patient and to the same degree as would be expected if the patient had remained in the ICU. Care givers at all levels should be impressed with the need for documentation of events occurring during transport. To ensure that the patient is transported by sufficient numbers of adequately trained personnel, a systematic evaluation of each patient should be undertaken prior to transport including relative stability of the patient. The equipment also must meet the need of the patient and be compatible with the required movement in terms of transportability, shock resistance, power supply, and ability to function in the procedure area.

Judging from the relative volume of literature and the individual nature of some transport systems devices by some hospitals and units, little attention has been paid to the intrahospital transport of the same patient after arrival. It is imperative that the health care systems address the issue of intrahospital transport in a systematic fashion so that no additional threat to survival is imposed. Being as one of the primary health care provider Emergency Department Hospital Universiti Sains Malaysia (HUSM), exposure to all above mentioned adverse events should be well addressed. Although there is lot of difference in term of equipments, facilities ad staffing, we are constantly expose to the situations that similarly occur in an ICU setup.

2. OBJECTIVES

General objective

To determine the prevalence of adverse events during transfer of critically ill patients Emergency Department to specialized units in HUSM.

Specific objectives

1. To determine the prevalence of adverse events during intrahospital transport of critically ill patient.
2. To determine the requirement of therapeutic interventions during transport.
3. To determine the factors which predict the occurrences of adverse events during transport.
4. To determine the factors which predict the requirement of major therapeutic interventions during transport.

2.2 RESEARCH HYPOTHESIS

The adverse events that occur during the transport are due to the transport process itself.

2.3 TERMINOLOGY

1. Shortcoming is defined as adverse event that occurred during transportation of critically ill patients.
2. An adverse event is defined as either a physiologic deterioration or an equipment-related mishaps and major therapeutic intervention that occurred during transport.
3. Physiologic deterioration during transport is defined as significant changes in vital signs, oxygen saturation, or arterial carbon dioxide.
4. A significant change in heart rate, respiratory rate, or blood pressure is defined as either a ≥20% change in pretransport values or change that is outside the normal range.
5. A significant change in oxygen saturation is defined as a reduction in oxygen saturation of ≥5% lasting ≥5 minutes.

6. Major intervention include fluid bolus of ≥20mL/kg body weight and/or vasoactive drug in response to hypotension, a change in ventilator settings in response to a decrease in oxygen saturation, or mannitol administration for an intracranial pressure of ≥20mmHg.
7. Intensity of therapy is measured by the Therapeutic Intervention Scoring System (TISS).
8. A mishap is defined as the occurrence of any unplanned event that potentially could have a detrimental effect on patients' stability.

Table 2: Type of Mishaps
Dislodged ETT/accidental extubation
Loss of oxygen supply
Lack of necessary equipment
Malfunction of equipment
Accidental removal or infiltration of a peripheral venous catheter
Loss of arterial, central venous or pulmonary venous catheter
Accidental removal of an indwelling catheter, chest, nasogastric, or tracheostomy tube
Error in the dose of medication
Omission or required dose of medication

3. LITERATURE REVIEW

By definition, all critically ill patients have not yet recovered their full physiologic stability and a period of transport is a period of potential instability. As with anaesthesia and surgery, the risk of transport may be less than, equal to, or exceed the risk of the procedure it self. Patients are usually transported because their condition has deteriorated and become less stable. Relative stabilization prior to transport will vary with the setting of transport origin (field, emergency department, and transfer from one ICU to another). A reasonable attempt should be made to stabilize the patient prior to interfacility transport. This may include invasive procedures and monitoring. Decisions regarding the extent of intervention are complex, however. Many procedures carry particular risks during transport (e.g., air embolus if central catheters disconnected), and abundant time is often not available. If the patient is in need of definitive surgery, stabilization procedures, or other therapy that is only available at the receiving facility, one should delay only for items essential to a safe transport.

3.1 Physiology of critically ill patient

3.1.1 Oxygen transport

The major function of the heart, lungs and circulation is the provision of oxygen and other nutrients to the various organs and tissues of the body. During this process carbon dioxide and the other waste products of metabolism are removed. The rate of supply and removal should match the specific metabolic requirements of the individual tissues. This requires adequate oxygen uptake in the lungs, global matching of delivery and consumption, and regional control of the circulation. Failure to supply sufficient oxygen to meet the metabolic requirements of the tissues is the cardinal feature of circulatory failure or 'shock'. The important points to note are that:

- The movement of oxygen from pulmonary capillary to systemic tissue capillary, referred to as the global oxygen delivery (*D*O2), relies on convection or bulk flow and is the product of cardiac output and arterial oxygen content.
- The regional distribution of oxygen delivery is vital. If skin and muscle receive high blood flows but the splanchnic bed does not, the gut will become hypoxic
- The major determinants of the oxygen content of arterial blood (*Ca*O2) are the arterial oxygen saturation of haemoglobin (*Sa*O2) and the haemoglobin concentration (over 95% of oxygen carried in the blood is attached to haemoglobin). The shape of the oxyhaemoglobin dissociation curve dictates that increases in *Pa*O2 beyond the level that ensures *Sa*O2 is > 90% produce relatively small additional increases in *Ca*O2 . Consider a patient who is both anaemic (Hb 60 g/l) and hypoxaemic (*Sa*O2 75%) when breathing air (*FI*O2 0.21). Supplementary oxygen at *FI*O2 0.4 will increase *Sa*O2 to 93%; *Ca*O2 will increase by 24% but further increases in *FI*O2 while increasing *Pa*O2 cannot produce any further useful increases in *Sa*O2 or *Ca*O2. However, increasing Hb to 90 g/l by blood transfusion will result in a further 50% increase in *Ca*O2.
- The movement of oxygen from tissue capillary to cell occurs by diffusion and depends on the gradient of oxygen partial pressures, diffusion distance and the ability of the cell to take up and use oxygen. Therefore microcirculatory, tissue

diffusion and cellular factors, as well as *D*O2, influence the oxygen status of the cell.

- Supranormal levels of oxygen delivery cannot compensate for diffusion problems between capillary and cell, nor for metabolic failure within the cell.

3.1.2 Oxyhaemoglobin dissociation curve

The oxyhaemoglobin dissociation curve describes the relationship between the saturation of haemoglobin (*S*O2) and the partial pressure (*P*O2) of oxygen in the blood. Due to the shape of the curve, a small drop in *Pa*O2 below 60 mmHg will cause a marked fall in *Sa*O2. Its position and the effect of various physico-chemical factors are defined by the *P*O2 at which 50% of the haemoglobin is saturated (*P*50), which is normally 26 mmHg. A shift in the curve will influence the uptake and release of oxygen by the haemoglobin molecule; for example, if the curve moves to the right, the haemoglobin saturation will be lower for any given oxygen tension and therefore less oxygen will be taken up in the lungs but more will be released to the tissues. As capillary *P*CO2 rises, the curve moves to the right, increasing unloading of oxygen in the tissues, a phenomenon known as the Bohr effect. Traditionally, the optimum haemoglobin concentration for critically ill patients had been considered to be approximately 100 g/l, representing a balance between regional microcirculatory problems due to increased viscosity. However, recent evidence suggests an improved outcome in critically ill patients if the haemoglobin concentration is maintained between 70 and 90 g/l, with the exception of the elderly and patients with coronary artery disease, in whom a level of 100 g/l remains appropriate. Further explanation can be described on Figure 3.1.2.

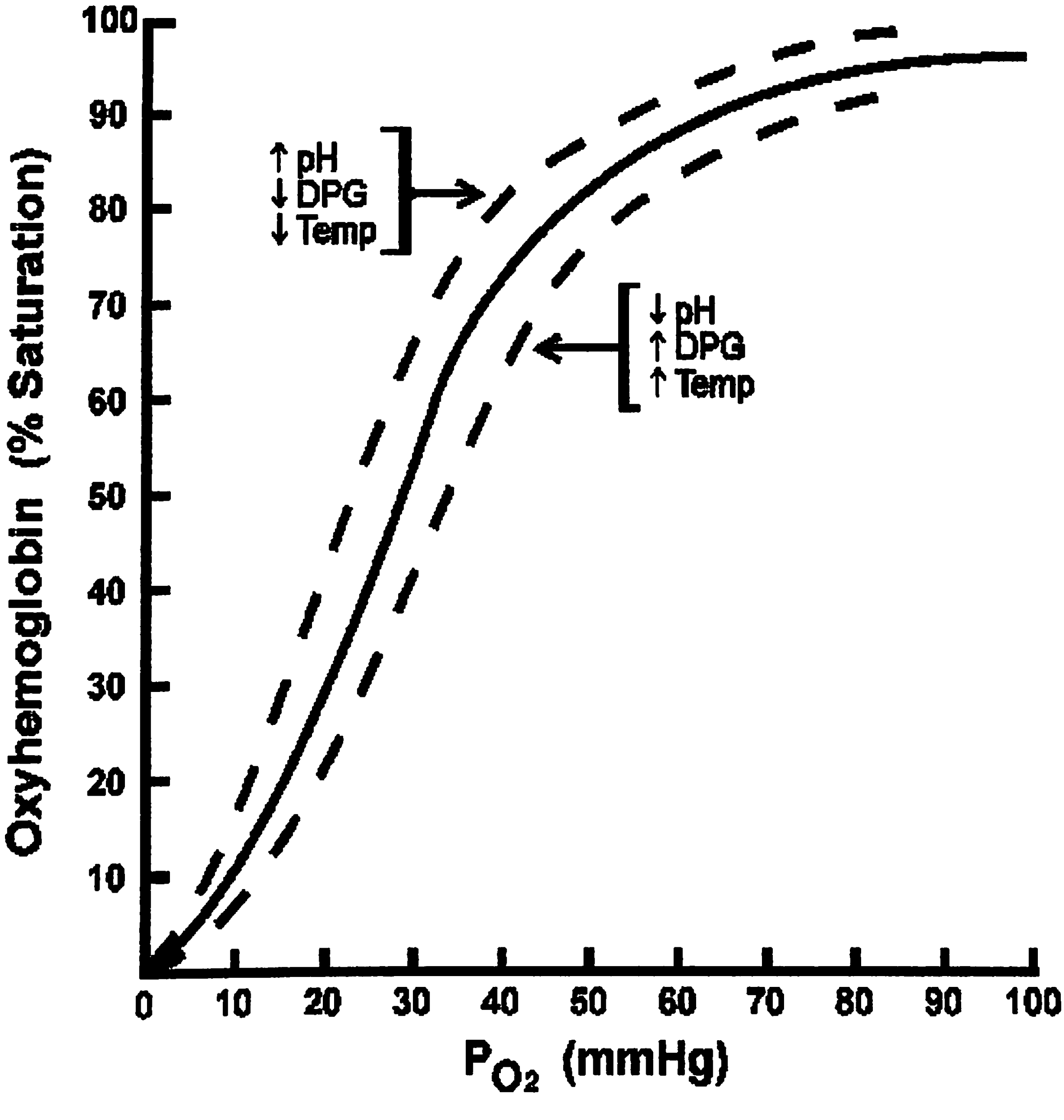

Figure 3.1.2: Graph of oxygen dissociation curve showing the effects of blood pH, body temperature and DPG on the affinity of oxygen to hemoglobin

3.1.3 Oxygen consumption

The sum of the oxygen consumed by the various organs represents the global oxygen consumption (*V*O2) and is approximately 250 ml/min for an adult of 70 kg undertaking normal daily activities. *V*O2 may be calculated indirectly from the product of cardiac output and the arterial mixed venous oxygen content difference (*Ca*O2–*Cv*O2), or directly by sampling the inspired and mixed-expired gases from the ventilator and measuring inspired and expired minute volume using either a mass spectrometer or metabolic cart. The oxygen saturation in the pulmonary artery, otherwise known as the mixed venous oxygen saturation (*Sv*O2), represents a measure of the oxygen not consumed by the tissues (*D*O2–*V*O2). The saturation of venous blood from different organs varies considerably; for example, the hepatic venous saturation usually does not exceed 60% but the renal venous saturation may reach 90%, reflecting the great difference in both the metabolic requirements of these organs and the oxygen content of the blood delivered to them. The *Sv*O2 is influenced by changes both in oxygen delivery (*D*O2) and consumption (*V*O2) and, provided the microcirculation and the mechanisms for cellular oxygen uptake are intact, can be used to monitor whether global oxygen delivery is adequate to meet overall demand. The reoxygenation of the blood that returns to the lungs and the resulting arterial saturation (*Sa*O2) will depend on how closely pulmonary ventilation and perfusion are matched. If a part of the pulmonary blood flow perfuses non-ventilated parts of the lung, there will be 'shunting', and the blood entering the left atrium will be desaturated in proportion to the size of this shunt and the level of *Sv*O2.

3.1.4 Relationship between oxygen consumption and delivery

The tissue oxygen extraction ratio (OER), which is 20–25% in a normal subject at rest, rises as consumption increases or supply diminishes. The maximum OER is approximately 60% for most tissues; at this point no further increase in extraction can occur and any further increase in oxygen consumption or decline in oxygen delivery will cause tissue hypoxia, anaerobic metabolism and increased lactic acid production. In sepsis the slope of maximum OER decreases, reflecting the reduced ability of tissues to extract oxygen, but the curve does not plateau and oxygen consumption continues to increase even at 'supranormal' levels of oxygen delivery. This concept encouraged some physicians to treat septic shock using vigorous intravenous fluid loading and inotropic support, usually with dobutamine, with the aim of achieving very high oxygen deliveries (> 600 ml/min/m2) in the belief that this strategy would increase oxygen consumption, relieve tissue hypoxia, prevent multiple organ failure and improve prognosis. Trials have demonstrated no benefit in ICU patients with established organ failure but suggest that it may be worthwhile if applied before organ failure supervenes.

3.1.5 Pathophysiology of inflammatory response

In critically ill patients these processes have important consequences. Fever, tachycardia with warm peripheries, tachypnoea and a raised white cell count traditionally prompt a diagnosis of sepsis with the implication that the clinical picture is caused by invading microorganisms and their breakdown products. However, other conditions such as pancreatitis, trauma, malignancy, tissue necrosis, aspiration syndromes, liver failure, blood transfusion and drug reactions can all produce the same clinical picture in the absence of infection.

Local inflammation

The body's initial response to a noxious local insult is to produce a local inflammatory response with sequestration and activation of white blood cells and the release of a variety of mediators to deal with the primary 'insult' and prevent further damage either locally or in distant organs. Normally, a delicate balance is achieved between pro- and anti-inflammatory mediators. However, if the inflammatory response is excessive, local control is lost and a large array of mediators including prostaglandins, leukotrienes, free oxygen radicals and particularly pro-inflammatory cytokines are released into the circulation. The inflammatory and coagulation cascades are intimately related. The process of blood clotting not only involves platelet activation and fibrin deposition but also causes activation of leucocytes and endothelial cells. Conversely, leucocyte activation induces tissue factor expression and initiates coagulation. Control of the coagulation cascade is achieved through the natural anticoagulants antithrombin (AT) III, activated protein C (APC) and tissue factor pathway inhibitor (TFPI) which not only regulate the initiation and amplification of the coagulation cascade but also inhibit the pro-inflammatory cytokines. Deficiency of ATIII and APC (features of disseminated intravascular coagulation (DIC), facilitates thrombin generation and promotes further endothelial cell dysfunction (Oh's Intensive Care Manual, 2003).

Systemic inflammation

During a severe inflammatory response systemic release of cytokines and other mediators triggers widespread interaction between the coagulation pathways, platelets, endothelial cells and white blood cells, particularly the polymorphonuclear cells (PMNs). These 'activated' PMNs express adhesion factors (selectins) causing them initially to adhere to and roll along the endothelium, then to adhere firmly and finally to migrate through the damaged and disrupted endothelium into the extravascular, interstitial space together with fluid and proteins, resulting in tissue oedema and inflammation. A vicious circle of endothelial injury, intravascular coagulation, microvascular occlusion, tissue damage and further release of inflammatory mediators ensues. All organs may become involved. This manifests in the lungs as the acute respiratory distress syndrome (ARDS) and in the kidneys as acute tubular necrosis (ATN), while widespread disruption of the coagulation system results in the clinical picture of DIC. The endothelium itself produces mediators that locally control blood vessel tone: endothelin 1, a potent vasoconstrictor, and prostacyclin and nitric oxide (NO) which are systemic vasodilators. NO (which is also generated outside the endothelium) is implicated in both the myocardial depression and the profoundly vasodilated circulation (both arterioles and venules) that causes the relative hypovolaemia and systemic hypotension found in septic/SIRS shock. A major component of the tissue damage in septic/SIRS shock is the inability to take up and use oxygen at mitochondrial level even if global oxygen delivery is supranormal. This effective bypassing of the tissues results in a reduced arteriovenous oxygen difference, a low oxygen extraction ratio, a raised plasma lactate and a paradoxically high mixed venous oxygen saturation (*Sv*O2). If both the precipitating cause and accompanying circulatory failure (hypotension and frequently severe hypovolaemia due to venodilatation and fluid loss through the leaky vascular endothelium) are promptly controlled before significant organ failure occurs ('early' shock), the prognosis is good. However, if the global and peripheral circulatory failure is not corrected promptly, and particularly if the underlying cause is not effectively treated, progressive deterioration in organ function occurs and multiple organ failure (MOF) ensues ('late' shock). The mortality of MOF is high and increases with the number of organs that have failed, the duration of organ failure and the patient's age. Failure of four or more organs is associated with a mortality > 80% (Respiratory Intensive Care, 2002).

3.2 Intrahospital transport

Transport of the critically ill patient within hospital for diagnostic or other procedure can be fraught with danger for many reasons. Patient dependent on technology, with its potential for failure or disconnect, and the frequent isolation of the patient from support personnel during the procedure make moving the patient from the relative security area to other hospital areas potentially life-threatening one study documented mishaps occurred in 34% of the patient transport (Smith I et al, 1990).

When admitted in the ER (Emergency Room), after being resuscitated, the critically ill patients are often transferred from the emergency rooms to the intensive care unit (ICU) or operating room and then to recovering rooms or ICU's. The patients with these characteristics sometimes still need to be removed in the hospital to therapeutical and diagnostic procedures. The technological improvement makes the transport of patients from ICU's to other places in the hospital, where the possibilities of emergency action are very often inappropriate, mostly the radiology services (computed tomography scan, nuclear magnetic resonance, invasive and non-invasive angiography) and nuclear medicine. The period of transport is characterized by a great instability to the patient, as its medical condition can eventually get worse with further complications, which should be expected. In accordance with the diagnostic test, if the team realizes that the transport represents a serious risk, a new evaluation of the situation should be done. Most of the literatures suggest the implementation of guidelines to introduce the minimum requirements, which should be available during the transport of any patient in serious condition. The transport in the hospital of the patient in serious condition should follow these rules:

3.2.1 Coordination before the transport (Adapted from Portuguese Society of Intensive Care: Guidelines For the Transport of Critically Ill Patients, 1997)

- Previous information that the area where the patient is meant to be moved is ready to receive him/her and to make the exam or planned therapy;
- The doctor in charge should go with the patient or whenever the transport of the patient is in charge of a different team, communication doctor to doctor and/or nurse to nurse should be established regarding the medical situation of the patient and the therapies, before and after the removal;
- Write in the medical record the events occurred during the transport and the evaluation of the condition of the patient.

3.2.2 Professionals with the patient

Two professionals (doctors/nurses) should accompany the patient in serious condition at least.

- One of the professionals should be the nurse in charge of the patient, with experience in CPR or specially trained in transport of patients in serious conditions;

- In accordance with the serious condition and the instability of the patient, the second professional can be a nurse or a doctor;
- A doctor should attend the patients who present physiological instability and eventually will need an emergent or urgent action.

3.2.3 Equipment to support the patient

- Transport monitor;
- Blood pressure reader;
- Endotracheal intubation kit, and manual resuscitator" (with PEEP valve);
- Oxygen source with a predictable capacity for the whole period of transport, with additional reserve for 30 minutes;
- Portable ventilator, with availability to offer volume/minute, pressure FiO2 of 100% and PEEP which the patient is doing previously, with disconnection alarm and high airway pressure alarm; during a pediatric transport the FiO2 should be accurately controlled;
- Drugs for resuscitation, namely adrenaline, lignocaine, atropine and sodium bicarbonate;
- Intravenous fluids and continuous infusion of drugs ruled by syringes or infusing pumps with battery to prevent any interruption;
- Additional medications to be administered according to the medical prescription.

Note: Somewhere on the road there should be available an aspirator and an emergency car in an average time of four minutes.

3.2.4 Monitoring during the transport

Note: The levels of monitoring were divided regarding the following classification:

Level 1 - compulsory;

Level 2 - highly recommended;

Level 3 - ideal.

- Continuous monitoring with periodical record:
  - ECG (level 1);
  - Pulse oximetry (level 1);
- Intermittent monitoring and record:
  - Blood pressure (level 1);
  - Heart rate (level 1);
  - Respiratory rates (level 1 in pediatrics and level 2 in other patients).
- In **selected** patients (regarding his/her medical condition):
  - Capnography (level 2);
  - Continuous measure of the blood pressure (level 3);
  - Measure of the pulmonary artery pressure (PAP) (level 3);
  - Measure of intracranial pressure (ICP) (level 3);
  - Intermittent measure of Central Venous Pressure (CVP) (level 3);
  - In patients intubated and mechanically ventilated the airway pressure (Paw) should be monitored (level 1 in these situations)

With adequate pre-transfer preparation, it is possible to transport even extremely sick ICU patients (Gervais HW, 1987). Gebremichael M et al reported the outcome of 39 patients with respiratory failure who underwent road transfer using a specially designed mobile intensive care unit, equipped and staffed to nearly recreate the intensive care environment. 72% of the patients had an arterial line, 67% pulmonary artery catheter, 56% of the patients needed vasoactive drugs, the mean positive end-expiratory pressure requirement of 15.9, a mean FIO_2 requirement of 0.93, and a mean PaO_2/FiO_2 ratio of 59.8. They had only one death during transport. Uusaro and colleagues (Link J, 1990) transported 66 unstable patients with ARDS & circulatory failure, over long-distance in customized ambulances. 89% of the patients had inotropes infusion and 21% were transferred in prone position due to life threatening hypoxia. There were no major complications during the transfer. This study demonstrated that long-distance interhospital ground transfers of even the most critically ill patients are safe, provided you have dedicated transport team, proper patient stabilization before transport, and a transport vehicle with intensive care facilities. Another group (Rossaint R et al, 1997) also reported successful transport of 8 severely hypoxemic ARDS patients requiring ECMO support without major complications. A retrospective case control Australian study (Duke GJ et al, 2001) carried out over 3 years found that critically ill patients undergoing acute interhospital transfer experience a delay in admission to ICU, and a longer length of stay in ICU and hospital when compared to their ICU counterparts who were not moved. However, there was no significant difference in hospital mortality between the two groups, and there were no deaths during transfer.

With currently available technology, it is possible to replicate the critical care environment required for transportation of virtually any patients. However, features of the transport environment can aggravate a patient's condition as well as alter or interrupt ongoing therapy. These represent some of the major risks during patient transportation. The goal of care during transport is to minimize these risks factor and provide care as necessary. Transportation critically ill patient differs from in-hospital care largely in the degree that pragmatics, logistics, and anticipation of needs play a role. It is unlikely a controlled study will ever prove that transportation of critically ill patient can be accomplished without alteration in outcome. However, large series of transport patients have been reported without evidence of major untoward events (Ehrenwerth J, 1986). Transport of patients in ground vehicles involves multiple movement risks. Extubation, dislodgment of intravascular lines or other equipment, and disconnection of drug infusion may occur. Scrupulous supervision to prevent such occurrences must be undertaken, particularly during transfers to and from stretcher to bed and vice versa. Patients transport may or may not arrive with adequate oxygen, suction equipment, or other supply and often provide only with basic life support equipment. It is best to maintain a preassembled collection of all transport equipment and supplies as part of the transport system. Transport personnel should never assume that short distances equal short time.

In moving a patient to and from a stretcher, there will be short periods of Trendelenburg and reverse Trendelenburg position especially when one personnel accompany patient although these episode usually not long enough to exacerbate pathophysiology states (e.g., shock, congestive heart failure, intracranial hypertension).

In addition, axial load changes are applied to the patient in traction or in head or spine fixation devices. The team must be the "patient stabilizer" in these situations.

Patients are usually transported because their condition has deteriorated and become less stable. Relative stabilization prior to transport will vary with the setting of transport origin (field, emergency department, and transfer from one ICU to another). A reasonable attempt should be made to stabilize the patient prior to interfacility transport. This may include invasive procedures and monitoring. Decisions regarding the extent of intervention are complex, however. Many procedures carry particular risks during transport (e.g., air embolus if central catheters disconnected), and abundant time is often not available. If the patient is in need of definitive surgery, stabilization procedures, or other therapy that is only available at the receiving facility, one should delay only for items essential to a safe transport.

3.3 Transport team

The composition of the transport team should be vary based on the specialty needs of the patient and the skill of team members. Organization to allow obstetric, paediatric, and intensive care physicians, nurses, and respiratory therapist to accompany the patient should be available. While some reports have suggested that patients can be transported safety by staff possessing only basic health care skills (Rubenstein D, 1988), it is the skill level and resources of the transport team that determine safety rather than the absolute speed of transport in most instances.