STUDY OF RELATIONSHIP OF VASCULAR PEDICLE WIDTH WITH CARDIOTHORACIC RATIO AND HEMODYNAMIC DATA IN VENTILATED ICU PATIENTS

By

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ABBREVIATIONS

cm	Centimeter
CR	Computed radiography
CTR	Cardiothoracic ratio
CT	Computed Tomography
CVP	Central Venous Pressure
ICU	Intensive Care unit
L	Liter
mm	Millimeter
p	Level of significance
PA	Posteroanterior
PAC	Pulmonary Artery Catheter
PAOP	Pulmonary Artery Occlusion Pressure
PEEP	Positive end expiratory pressure
r	Correlation coefficient
SD	Standard deviation
SVC	Superior Vena Cava
TBV	Total Blood Volume
VPW	Vascular Pedicle Width

ABSTRAK

Bahasa Melayu

Tajuk:

Perkaitan antara ukuran *vascular pedicle width* dan nisbah kardiotorasik dengan data hemodinamik untuk pesakit – pesakit yang menggunakan mesin bantuan pernafasan di Unit Rawatan Rapi

Latar belakang:

Tahap berlebihan cecair dalam badan adalah salah satu perkara yang amat dititikberatkan dalam rawatan pesakit yang menggunakan mesin bantuan pernafasan di unit rawatan rapi. Pengawasan tahap cecair darah selalunya menggunakan 'pulmonary artery catheter' atau 'CVP catheter' yang mempunyai kesan sampingan yang serius seperti jangkitan kuman, jangkitan yang merebak ke jantung dan salur darah yang tersumbat. Kini, kaedah pengawasan tahap berlebihan cecair dalam badan telah mendapat tempat disebabkan kesan sampingan kaedah yang terdahulu. Radiografi dada adalah kaedah pengawasan yang sering dillakukan di unit rawatan rapi dan merupakan cara pengawasan tahap berlebihan cecair dalam badan yang selamat. Tetapi, disebabkan penganalisaan radiografi dada, adalah lebih subjektif, kaedah yang lebih objektif diperlukan untuk menentukan tahap berlebihan cecair dalam badan.

Objektif:

Untuk menentukan hubungkait diantara 'vascular pedicle width' dengan data hemodinamik (berat dan CVP) dan nisbah kardiotorasik di kalangan pesakit yang menggunakan mesin bantuan pernafasan.

Metodologi:

Kajian ini adalah kajian 'cross sectional' yang dilakukan daripada Mei 2006 sehingga Disember 2006 dan melibatkan seramai 140 pesakit yang menggunakan mesin bantuan pernafasan di unit rawatan rapi. Berat badan dan 'CVP' dibaca dalam tempoh satu jam selepas radiografi dada diambil. Radiografi dada digital digunakan untuk pengukuran VPW pada tempat yang berasingan, di mana data klinikal pesakit tidak didedahkan.

Keputusan:

Seratus empat puluh pesakit yang menggunakan mesin bantuan hayat terlibat dalam kajian ini. Seramai 73 daripada keseluruhan pesakit adalah lelaki dan 67 adalah pesakit perempuan. Seramai 122 pesakit adalah bangsa melayu dan (87%) dan 18 (13%) pesakit adalah bangsa Cina. Nilai purata untuk umur pesakit adalah 46.6 tahun dan untuk berat pesakit adalah 62.6 kg. Nilai purata untuk ukuran VPW adalah 64.3 mm, CTR adalah 0.5 dan untuk CVP adalah 13.0 mmHg respectively. Terdapat hubungkait yang ketara di antara berat pesakit dengan VPW ($p<0.001$), CVP dengan VPW ($p<0.001$) dan CTR dengan VPW ($p<0.001$). Dengan menggunakan analisa 'multiple linear regression', didapati hanya CTR yang mempunyai hubungkait yang paling ketara dengan VPW jika

dibandingkan dengan berat pesakit dan CVP. Hanya ukuran VPW didapati mempunyai hubungkait dengan paru-paru berair (pulmonary edema) ($p<0.001$) di kalangan pesakit yang terlibat dan ini dibuktikan dengan menggubakan analisa statistic 'multiple logistic regression'. Keputusan juga menunjukkan bahawa apabila ukuran VPW meningkat sebanyak 0.17 mm, risiko untuk mendapat paru-paru berair meningkat sebanyak 1.2 kali ganda ($p<0.001$).

Kesimpulan:

Terdapat hubungkait yang signifikan di antara berat badan, CVP dan CTR pesakit dengan ukuran VPW. Hubungkait yang paling signifikan diperolehi di antara CTR dengan ukuran VPW. Hanya ukuran VPW yang mempunyai hubungkait dengan pesakit yang mengalami paru-paru berair (pulmonary edema). Apabila ukuran VPW meningkat sebanyak 0.17 mm, risiko untuk mendapat paru-paru berair meningkat sebanyak 1.2 kali ganda. Nilai purata untuk ukuran VPW didapati lebih kecil berbanding kajian lain. Ini menunjukkan bahawa kemungkinan had ukuran VPW yang digunakan untuk menentukan tahap cecair badan yang berlebihan atau kurang adalah lebih kecil untuk ukuran badan populasi kita.

ABSTRACT

English

Title:

The relationship of vascular pedicle width with cardiothoracic ratio, weight and CVP in ventilated ICU patients.

Background:

Intravascular volume assessment is one of the main concern in managing critically ill ventilated patients. Invasive hemodynamic monitoring is commonly used to assess the intravascular volume status. Due to its invasiveness and other related serious complications such as bacteremia, endocarditis and thrombogenesis, the non-invasive diagnostic testing has gained increase importance. Chest radiograph is the readily available and commonest tool used in managing critically ill ventilated patients. It is one of invasive method to determine the intravascular volume status. However, due to subjectivity on interpreting chest radiograph, an objective measurement like VPW is used to assess intravascular volume.

Objectives:

To determine the relationship of vascular pedicle width with hemodynamic data (weight and CVP) and CTR in ventilated patient using supine portable chest radiograph.

Methodology:

A cross sectional study was done from May 2006 until December 2006 involving 140 adult ventilated patients in ICU and Neuroscience ICU of Hospital University Sains Malaysia. The hemodynamic data (weight and CVP) was read within 1 hour after the chest radiograph performed. Computed chest radiography is used for evaluation of the VPW. The VPW and CTR were measured by researcher in separated occasion without clinical data related to patients available.

Results:

One hundred and forty adult ventilated patients were included in this study. Out of 140 subjects, 73 were male and 67 patients were female. One hundred twenty two out of 140 patients were Malays (87%) whereas 18 (13%) were Chinese. The mean age was 46.6 years old and the mean weight was 62.6 kg. The mean value for VPW was 64.3 mm and the mean value for CTR and CVP was 0.5 and 13.0 mmHg respectively. There was significant relationship between weight with VPW ($p<0.001$), CVP with VPW ($p<0.001$) and CTR with VPW ($p<0.001$). However, using the multiple linear regression analysis, it is found that only CTR has a significant relationship with VPW as compare to weight and CVP. The VPW was found to be the only association seen with pulmonary edema among study population ($p<0.001$) by using the multiple logistic regression analysis. When there is increased of VPW measurement by 0.17 mm, the patients will have 1.2 time risk of having pulmonary edema ($p<0.001$).

Conclusion:

There was statically significant correlation seen between the weight, CVP and CTR with the VPW. The most significant correlation was seen between CTR with VPW. The VPW was the only associated seen with pulmonary edema. When there is increased of VPW measurement by 0.17 mm, the patients will have 1.2 time risk of having pulmonary edema. The mean value of VPW was noted to be smaller as compared to other previous study. This suggest that the cut off VPW measurement used to differentiated between high to low or normal intravascular volume could be smaller in our population body habitus.

CHAPTER 1:

INTRODUCTION

CHAPTER 1: INTRODUCTION

Most of the ventilated ICU patients are monitored with portable chest radiograph on a daily basis. Portable chest radiograph is the mostly used noninvasive study to identify the presence of pulmonary edema and also to assess severity or change in pulmonary edema in those patients. Interpreting chest radiograph is rather subjective, thus leads to interobserver variability. The experience doctors may give different impression as inexperience ones. Therefore, a standard qualitative (objective) measurement of chest radiograph to identify or assess pulmonary edema is important to reduce this variability.

The intravascular volume status and fluid balance are essential components of ICU patient management that is strongly related to clinical outcome. The assessment of intravascular volume status of the critically ill patients may be difficult. Usually in ICU, assessment of the intravascular volume status, the Swan-Ganz catheter or central venous catheter is used. However, there is limitation with the method due to its invasiveness and other serious related complications such as bacteremia, endocarditis, and thrombogenesis. As the concern regarding the efficacy and safety of this catheterization, the noninvasive diagnostic testing has gained increase important to evaluate the hemodynamic status.

In our setting, the commonest tool used in assessing the intravascular fluid status is chest radiograph in combination with central venous catheter measurement. The supine chest radiographs is probably the cheapest and only non-invasive method to determine the volume status and readily available. Over the last few decades, researchers have been trying to correlate between measurement of large vessels on chest radiograph with estimation of intravascular fluid volume and overall body fluid content. The VPW is the mediastinal silhouette of the great vessels, remains the main focus of this discussion. Study done by Pistolesi *et al.*, (1984) used these measurements in patients with heart diseases. He found that azygos vein correlate poorly with systemic blood volume ($r= 0.50$, $p<0.01$). However, the VPW correlated strongly with change of total blood volume ($r= 0.93$, $p<0.001$). Later on, Ely *et al.*, (2002) studied relationship of width of vascular pedicle and Pulmonary Artery Occlusion Pressure and showed that the VPW correlated with pulmonary artery occlusion pressure (r=0.45, p=0.00b).It also noted in this study that the best cutoff for differentiating a high versus normal to low intravascular volume is 70 mm (Ely *et al.*, 2002).

As the previous study had been done on Caucasians, known to have different body habitus as compared to Asian, we believe this study is needed to prove that the similar VPW measurement can be reproducible to identify or to assess the status of pulmonary edema.

There is no intention to replace the role of pulmonary artery catheter (PAC) or CVP by conducting more studies in noninvasive methods. We believe they will remain a major role in ICU. However, with this noninvasive parameter of VPW on chest radiograph, the identification of patients for more invasive monitoring such as PAC or CVP insertion can be made objectively. This study, attempts to find the relationship of

CVP and VPW. The CVP has been chosen because of its frequency of insertion is higher and more common as compared to pulmonary artery catheter.

The assessment of VPW is relatively new in our regional setting; therefore it is best to implement VPW measurement in ICU patients – as what VPW intended for. On the other hand, by using VPW, we further utilized chest radiograph as our commonest tool in assessing the fluid status without additional cost.

This study is a combined study between the Department Of Radiology and the Department Of Anaesthesiology.

CHAPTER 2:

LITERATURE REVIEW

CHAPTER 2: LITERATURE REVIEW

2.1 BEDSIDE CHEST RADIOGRAPHY

The patients in ICU are usually critically ill. They are monitored and supported by various mechanical devices. The chest radiograph is the commonest tool used by clinicians for verification of catheter or tube placements and detection of complications or evaluation of cardiopulmonary status. It plays a crucial role in diagnosing and managing the fluid status of ICU patients. It is also the most commonly used in noninvasive studies to identify the presence, severity, or change in pulmonary edema in the ICU (Ely *et al.,* 2001). The clinical demand for bedside chest radiograph has made it increasingly important radiology investigations. Almost all critically ill patients undergo bedside chest radiograph daily. These examinations are useful in about 76%-94% of the time (Wandtke J *et al.*, 1994).

2.1.1 IMAGE QUALITY IN CONVENTIONAL PORTABLE CHEST RADIOGRAPH

Despite the many advantages of bedside radiograph, there are well-recognized limitations. The exposure variations constitute to one of the most obvious technical difficulties in bedside radiography in a conventional radiography. The quality of the conventional chest radiograph is highly variable, and the average quality is generally poor compared to that performed with fixed equipment in radiology department. As a result, the accuracy of diagnosis is impaired. Currently, exposure control is solved for this particular problem with computed radiography.

2.1.2 IMAGE QUALITY OF COMPUTED RADIOGRAPHY

Computed radiography (CR) uses a special solid-state detector plate instead of a film inside a cassette. The exterior dimensions and appearance of the CR cassette is similar to those of conventional radiography. The CR cassette is placed in a bucky tray and exposed in the similar manner as a conventional radiography. The resolution of CR systems depends on the pixel size (Markus K *et al.*, 2007). The contrast resolution is superior to that of conventional radiography. Unlike conventional radiography images, the contrast, speed and latitude of CR images can be altered after they have been recorded and stored. This is the advantages of CR whereby it has the ability to adjust the contrast that has been recorded and able to emphasize important features, or to transfer the images to workstation using picture archiving and communications systems (PACS). It will help to improved contrast throughout the image and allow better visualization of low-contrast regions, such as the mediastinum (Ishigaki T *et al.*, 1996). Thus, for the VPW measurement (as explained later in section 2.3), the determination of the point at which the left subclavian artery exits and the point where the superior vena cava crosses the right main bronchus is better seen by adjusting the contrast. In this study, portable CR of the chest is used and each radiograph is displayed for interpretation on workstation with computerized calipers used for objective radiographic measurement of VPW and CTR.

2.2 MONITORING INTRAVASCULAR VOLUME IN INTENSIVE CARE UNIT

2.2.1 PULMONARY EDEMA

Pulmonary edema is an abnormal accumulation of fluid in the interstitial compartment of the lung with or without associated air-space filling. The edema maybe due to changes in hydrostatic forces in the capillaries, increased capillary permeability or to impairment of lymphatic drainage. Transudative pulmonary edema is due to increased hydrostatic pressure or, rarely, due to decreased oncotic pressure across a functioning capillary membrane. The development of pulmonary edema is common and sometimes life-threatening, especially in ICU patients.

Hydrostatic pulmonary edema is classified into 2 categories, those are cardiogenic and noncardiogenic (Milne *et al.*, 1985);

i) Cardiogenic pulmonary edema: commonly resulting from myocardial or valvular heart disease.

ii) Noncardiogenic pulmonary edema:

   a) Overhydration: Usually caused by excess saline effusion or renal failure with retention of salt and water.

   b) Capillary permeability: Can be caused by a wide variety of pathologic, traumatic, or infective conditions resulting in injury to the pulmonary vasculature.

Pulmonary edema cannot be detected at an early stage or diagnosed accurately by physical examination alone. In order to avoid life-threatening complications, prompt recognition of pulmonary edema is important. The use of chest radiography and other tests are the key to establish the condition and distinguishing between the 2 types of pulmonary edema (Milne *et al.*, 1985).

2.2.2 DETERMINATION OF THE CAUSES OF EDEMA USING CENTRAL VENOUS PRESSURE

The central venous pressure (CVP) is considered a direct measurement of the blood pressure in the right atrium and vena cava. It is acquired by threading a central venous catheter into any of several large mediastinal veins. It is usually threaded so that the tip of the catheter rests in the lower third of the superior vena cava. The pressure monitoring assembly is attached to the distal port of a multilumen central venous catheter. The CVP catheter is an important tool used to assess right ventricular function and systemic fluid status. The normal CVP reading ranges from 2-6 mm Hg (Clark FL, 2005).

- CVP is elevated by :
    - Overhydration results from increases venous return
    - Heart failure or PA stenosis which limit venous outflow and lead to venous congestion
    - Positive pressure which includes breathing, straining, coughing, etc.

- CVP decreases with:
    - Hypovolemic shock from hemorrhage, fluid shift or dehydration
    - Negative pressure breathing which occurs when the patient demonstrates retractions or mechanical negative pressure which is sometimes used for high spinal cord injuries.

In this study, CVP is used as this is the most common volume monitoring used in ICU in HUSM as compared to PAC.

2.2.3 THE DETERMINATION OF THE CAUSES OF EDEMA USING PULMONARY ARTERY CATHETER (PAC)

The pulmonary artery catheter is frequently referred to as a Swan-Ganz catheter, in honor of its inventors Jeremy Swan and William Ganz, from Cedars-Sinai Medical Center. Pulmonary artery catheterization (PAC) is the insertion of a catheter into a pulmonary artery. Its purpose is diagnostic; it is used to detect heart failure or sepsis, monitor therapy, and evaluate the effects of drugs. The pulmonary artery catheter allows direct, simultaneous measurement of pressures in the right atrium, right ventricle, pulmonary artery, and the filling pressure ("wedge" pressure) of the left atrium. The hemodynamic standard for diagnosis of volume overload is a pulmonary capillary wedge pressure (PCWP) of more than 18 mmHg (Benard *et al.*, 1994). The usage of the PAC is used in critical care units certainly provide a valuable clue to the type and management of edema. However, PAC remains an invasive procedure with some morbidity. This