BRIEF COMMUNICATION

Rev Bras Cir Cardiovasc 2007; 22(4): 509-512

Pre and post-pulmonary thromboendarterectomies campnographic variables

Variáveis capnográficas pré e pós-tromboendarterectomias pulmonares

Marcos Mello MOREIRA[1], Renato Giusepe Giovani TERZI[2], Reinaldo Wilson VIEIRA[3], Orlando PETRUCCI JUNIOR[4], Ilma Aparecida PASCHOAL[5], Pedro Paulo Martins de OLIVEIRA[6], Karlos Alexandre de Souza VILARINHO[7], Domingo Marcolino BRAILE[8]

RBCCV 44205-938

Abstract

In these case report, the results of late dead space fraction (fDlate), end-tidal alveolar dead space fraction (AVDSf), arterial-alveolar gradient CO_2 [P(a-et)CO_2], and slope phase 3 of spirogram of two patients who underwent thromboendarterectomy for pulmonary embolism (PE) are shown. PE was diagnosed by pulmonary scintigraphy, helical tomography, and pulmonary angiography. The calculation of fDlate, AVDSf and P(a-et)CO_2 was based on volumetric capnography associated with arterial blood gas analysis. The pre-operative fDlate of the first patient was 0.16 (cutoff 0.12) and AVDSf was 0.30 (cutoff 0.15). However, the fDlate of the second patient was false-negative (0.01) but, the AVDSf was positive (0.28). Postoperative fDlate of the first patient was -0.04 and AVDSf was 0.16; for the second patient, the values were 0.07 and 0.28, respectively. The association of these

1. Master degree; Post-graduate student – Department of Surgery - Faculdade de Ciências Médicas da Universidade Estadual de Campinas (FCM UNICAMP).*
2. Full Professor – Departament of Surgery - Faculdade de Ciências Médicas da Universidade Estadual de Campinas; Guest Lecturer - FCM UNICAMP.*
3. Associate Professor – Discipline of Heart Surgery - Faculdade de Ciências Médicas da Universidade Estadual de Campinas; Heart Surgery Discipline Coordinator - UNICAMP.**
4. Doctorate; Professor Assistente FCM UNICAMP.*
5. Ph.D. Professor – Discipline of Pneumology – Departament of Medical Clinic - Faculdade de Ciências Médicas da Universidade Estadual de Campinas*; Head of Pneumology Discipline – UNICAMP.**
6. Master Degree in Surgery - FCM UNICAMP; Assistant Physician – Discipline of Heart Surgery – UNICAMP.*
7. Post-graduate Surgical Student - FCM UNICAMP*; Assitant Physician - Discipline Heart Surgery – UNICAMP.**
8. Ph.D. Professor. - São José do Rio Preto Medical School and Unicamp. Director of Post Graduation – São José do Rio Preto Medical School. Editor of the Brazilian Journal of Cardiovascular Surgery.

This study was carried out at the Hospital de Clínicas*** da Faculdade de Ciências Médicas da Universidade Estadual de Campinas – UNICAMP, Campinas, SP.
* Faculty of Medical Sciences – State University of Campinas
** State University of Campinas
*** Clinics Hospital of the State University of Campinas

Correspondence address:
Orlando Petrucci Jr. Rua João Baptista Geraldi, 135 - Res Barão do Café - Barão Geraldo - Campinas – SP. CEP 13085-020
E-mail address: orlandopetrucci@gmail.com

Received: 26 Jul 2007
Accepted: 9 Oct 2007

capnographic variables with image exams reinforces the importance of this noninvasive diagnosis method.

Descriptors: **Pulmonary embolism. Pulmonary gas exchange. Capnography.**

Resumo

Este relato de dois casos com os resultados da fração tardia de espaço morto (*fDlate*), fração do espaço morto alveolar *end-tidal* (AVDSf), gradiente artério-alveolar de CO_2 [P(a-et)CO_2] e *slope* da fase 3 do espirograma, submetidos à tromboendarterectomia pulmonar por tromboembolismo pulmonar (TEP). O TEP foi diagnosticado pela cintilografia pulmonar, tomografia helicoidal computadorizada e por arteriografia pulmonar. O cálculo da *fDlate*, AVDSf e P(a-et)CO_2 baseou-se na capnografia volumétrica associada à gasometria arterial. A *fDlate* pré-operatória do primeiro paciente foi de 0,16 (*cutoff* de 0,12) e a AVDSf = 0,30 (*cutoff* de 0,15). Já a *fDlate* do segundo paciente resultou falso-negativa (0,01), embora a AVDSf resultasse positiva (0,28). A *fDlate* pós-operatória do primeiro paciente foi de -0,04 e a AVDSf de 0,16; a *fDlate* do segundo paciente foi de 0,07 e a AVDSf = 0,28. A associação destas variáveis com os exames por imagem reforça a importância deste método como ferramenta diagnóstica não-invasiva no diagnóstico de TEP.

Descritores: **Embolia pulmonar. Troca gasosa pulmonar. Capnografia.**

INTRODUCTION

It is well-known that unexpected death can occur in consequence of pulmonary thromboembolism (PTE) and anticoagulation is often effective in reducing the possibility of a new embolic event and death. For this reason, in patients in whom PTE is suspected, noninvasive methods would be preferred and available to be incorporated as part of bedside evaluation. Bedside techniques to evaluate patients with PTE are based upon a few respiratory parameters derived from the alveolar dead space. However, these variables have some limitations due to the difficulty to distinguish patients with PTE from those with other chronic obstructive pulmonary diseases (COPD). In order to overcome this difficulty, Eriksson et al. [1] described a diagrammatical method to extrapolate arterial-alveolar gradient [P(a-ET)CO2] to a late virtual expiration. This variable is called late dead space fraction (*fDlate*). The authors have performed a study enrolling 38 patients with suspected PTE and observed that *fDalte* was above than 0.12 in normal individuals, and in patients with COPD *fDlate* was below than 0.12. Another capnographic variable, the end-tidal alveolar dead space fraction (AVDSf) [2] calculate from the equation $PaCO_2$ - $PetCO_2$ / $PaCO_2$, "corrected" *fDalte* false-negative result. In the present two-case report, it was possible to correlate the result of pulmonary artery pre and post-thromboendarterectomy scan with *fDlate*, AVDSf, and the CO2 arterial-alveolar gradient [P(a-ET)CO2].

METHODS

Patient 1

A male patient, aged 69-year-old, was admitted to general ward with a history of dyspnea, palpitation, and dry cough, and later referred to the ICU; he denied pneumopathy and smoking. Physical examination revealed arrhythmic pulse and subtle hepatomegaly. Arterial blood gases revealed hypoxemia (P_aO_2 = 48.8 mmHg) and hypocapnia ($PaCO_2$ = 31mmHg). Echocardiogram showed mild increase of the right ventricle, pulmonary artery hypertension with an estimated systolic pressure of 76 mmHg and thrombus size of 30 x 20 mm in the right atrium. With PTE as a diagnostic hypothesis, a complete anticoagulation with unfractioned heparin was started. The patient was maintained on oxygen therapy through an air-entrainment (Venturi) mask. Ventilation/perfusion pulmonary scintigraphy showed multiple hypoperfusion areas compatible with difuse pulmonary embolization. Helical computed tomography (HCT) showed the presence of thrombi in the right and left pulmonary arteries spanning to their posterior segmental arteries. Taking into consideration the patient's history of over a two-week evolution and the maintenance of hemodynamics and clinical stability, extensive chronic embolism was suspected and chemical thrombolysis was contraindicated. After hemodynamic evaluation, a pulmonary thromboendarterectomy was performed [3].

Patient 2

A 42-year-old male heavy smoker patient (30 cigarettes a day over 15 years) presented on physical examination antiphospholipid antibody syndrome dyspnea to minor exertions and normothermia. Arterial blood gases revealed hypoxemia with PaO_2 = 64.9 mmHg, $PaCO_2$ = 31.4 mmHg, and sO_2 = 92.9%. Echocardiogram showed pulmonary artery hypertension with an estimate systolic pressure of 75 mmHg and a large thrombus (17 x 67 mm) adhered to right ventricle (RV) anterior wall occluding its outflow tract. Pulmonary scintigraphy showed perfusion failure on right and left lungs basal segments. HCT showed right ventricular filling pressure failure compatible with left descending interlobar artery thromboembolism with areas of pulmonary infarction in lower lobe of left lung. This patient was considered for surgical treatment because of right ventricle occlusion, besides presenting right pulmonary artery thromboembolism, which was highlighted by arteriography. Left pulmonary artery was embolus-free.

Volumetric capnography was recorded using a respiratory profile monitor CO2MO Plus 8100® (Dixtal/ Novametrix). Capnographic data were recorded for a 3 to 5-minute time at room temperature. Arterial blood gases were obtained afterwards [4]. *fDlate* was calculated after determining late PetCo2, i.e., extrapolated to 15% of Total Lung Capacity (TLCp) according to Eriksson et al. [1] using the following equation:

$$fDlate = PaCO_2 - Pet(15\%\ TLCp)CO_2/PaCO_2$$

where $PaCO_2$ is the partial pressure of carbon dioxide tension of arterial blood; Pet (15% TLCp) CO2 is the partial pressure of CO2 in the air expired extrapolated to 15% TLCp. TLCp (Total Lung Capacity) is obtained through the previous published Table and it is based on patient's age, weight, and height [3].

AVDSf [2] was calculated using the following equation:

$$AVDSf = PaCO_2 - PetCO_2/PaCO_2$$

Operative technique

On patient 1, pulmonary arteriotomy with thromboendarterectomy of its right and left branches was performed using cardiopulmonary bypass support and deep hypothermic circulatory arrest. After arteriorrhaphy and warming of the patient, the cardiopulmonary bypass was interrupted. The patient was discharged from hospital on postoperative day 6. On patient 2, a bulky thrombus with a diameter size of nearly 70 mm, which was occluding the right ventricle outflow tract, was removed and right pulmonary artery thromboendarterectomy using cardiopulmonary bypass support without deep hypothermia. Patient was discharged from hospital on postoperative day 13. Before hospital discharge both patients underwent a new pulmonary perfusion scintigram, which highlighted a significant improvement on patient 1. On patient 2, it was observed a subtle significant improvement in middle and superior thirds of both lungs; worsening in inferior lobe segments, and improvement of dyspnea on minor exertion. *fDlate*, AVDSf, $P(a\text{-}et)Co_2$, and *slope* 3 pre and postoperative values can be observed on Table 1.

DISCUSSION

Verschuren et al. [5] observed that after chemical thrombolysis to PTE, *Slope* 3 value increased, what reflected perfusion improvement and consequent reduction of both dead space fraction and $P(a\text{-}et)CO_2$. In another study, Thys et al. [6] observed AVDSf and $P(a\text{-}et)CO_2$ improvement after the same treatment. With surgical treatment, we observed the same as for patient 1 with confirmation by control scintigram as for patient 2. Patient 2 presented capnographic consistent variables when compared to control scintrigram, even though clinical improvement was referred.

In summary, patient 1 presented a PTE diagnosis by *fDlate* e AVDSf values, which were confirmed by preoperative images and improvement of postoperative images as well as the capnographic variables. Patient 2 presented a PTE diagnosis by both two capnographic variables studied and preoperative image methods; however, on postoperative period, *fDlate* presented improvement and AVDSf did not, which was confirmed by image methods. Consequently, there was a false *fDlate* improvement. Thus, the two capnographic variables should be used asd a whole to achieve a specificity and sensitivity method improvement.

Paschoal et al. [7], comparing capnographic data of a sample comprising 108 patients with suspected PTE and 114 healthy volunteers, identified a volunteer *Slope* 3 value of 7.80±2.36. The first patient presented a mean *Slope* 3 value (Table 1) slightly higher than the control group, what can explain the fact of AVDSf variable turns to be higher when compared to *fDlate*. The second patient presented a double *Slope* 3 value, what explains the fact of a negative *fDlate*. *fDlate* is direct related to *Slope* 3, what does not happen to AVDSf and $P(a\text{-}et)CO_2$ variables. Such a situation suggests that when a patient presenting *Slope* 3 higher than the control group value, AVDSf e a P(a-et)CO2 must be considered, in order to avoid a likely *fDlate* false-negative outcome. In any case, by applying the two variables, a 100% PTE sensitivity was obtained.

Table 1. Values of Pre- and Postoperative Gradients and Capnographic variables

	Preoperative				Postoperative			
	fDlate	AVDSf	Slope 3 (mmHg/L)	$P(a\text{-}et)\ CO_2$(mmHg)	fDlate	AVDSf	Slope 3(mmHg/L)	$P(a\text{-}et)CO_2$(mmHg)
Pac. 1	0.16	0.30	10.06	9.3	- 0.04	0.16	13.50	4.4
Pac. 2	0.01	0.28	16.20	8.5	0.07	0.28	16.48	9.5

In a recent study using clinical data D-dimer and AVDSf, Rodger et al. [8] stated that by applying two variables of this protocol in patients presenting to the Emergency Room with PTE suspected, one can eliminate the need for diagnostic imaging by 36%.

On the other hand, in developing countries, the diagnostic imaging test is not always available. For this reason, noninvasive methods to rule out the possibility of PTE would considerably reduce the number of patients unnecessarily undergoing diagnostic imaging test even in hospitals where these tests are available. Noninvasive tests could be used also in small hospitals where these diagnostic imaging tests are not available aiming at to select the patients to be transferred to a referral facility to perform the diagnostic imaging test.

In the present case reports, it was presented two patients with PTE diagnosis confirmed by diagnostic imaging tests and volumetric capnography whenthe later was judiciously used taking into consideration the information known up to the present time.

Study limitations

No doubts, the small number of patients (n=2) is a limitation, but what is being discussed in the present study is a diagnosis proposal that need to be better study in the future.

REFERENCES

1. Eriksson L, Wollmer P, Olsson CG. Diagnosis of pulmonary embolism based upon alveolar dead space analysis. Chest. 1989;96(2):357-62.

2. Rodger MA, Jones G, Rasuli P, Raymond F, Djunaedi H, Bredeson CN, et al. Steady-state end-tidal alveolar dead space fraction and D-dimer: bedside tests to exclude pulmonary embolism. Chest. 2001;120(1):115-9.

3. Moreira MM, Terzi RGG, Vieira RW, Petrucci Jr O. Fração tardia do espaço morto (fDlate) antes e após embolectomia pulmonar. Rev Bras Cir Cardiovasc. 2005;20(1):81-4.

4. Grimby G, Söderholm B. Spirometric studies in normal subjects. III Static lung volumes and maximum voluntary ventilation in adults with a note on physical fitness. Acta Med Scand. 1963;173:199-205.

5. Verschuren F, Heinonen E, Clause D, Roeseler J, Thys F, Meert P, et al. Volumetric capnography as a bedside monitoring of thrombolysis in major pulmonary embolism. Intensive Care Med. 2004;30(11):2129-32.

6. Thys F, Elamly A, Marion E, Roeseler J, Janssens P, El Gariani A, et al. PaCO(2)/ETCO(2) gradient: early indicator of thrombolysis efficacy in a massive pulmonary embolism. Resuscitation. 2001;49(1):105-8.

7. Paschoal IA, Moreira MM, Pereira ST. Noninvasive evaluation of pulmonary disease using volumetric capnography in adult patients with chronic pulmonary obstructive disease. J Cystic Fibrosis 2007;6(suppl. I):S38.

8. Rodger MA, Bredeson CN, Jones G, Rasuli P, Raymond F, Clement AM, et al. The bedside investigation of pulmonary embolism diagnosis study: a double-blind randomized controlled trial comparing combinations of 3 bedside tests vs ventilation-perfusion scan for the initial investigation of suspected pulmonary embolism. Arch Intern Med. 2006;166(2):181-7.