A comparison between right atrial and pulmonary arterial oxygen tensions

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Summary

Oxygen tensions of 50 simultaneously withdrawn blood samples from the right atrial orifice of a triple-lumen pulmonary artery catheter and from the pulmonary artery lumen were compared. Mixed venous oxygen tensions ranged from 21 mmHg to 44.9 mmHg. The correlation coefficient was 0.96 (t = 2.09; P = 0.01). The benefits and drawbacks of intermittent right atrial oxygen tension monitoring are discussed.

The central veins, superior vena cava, right atrium and pulmonary artery are now often used for the measurement of oxygen tension and oxygen saturation. In fact, the new fibre-optic catheter has popularized continuous measurement of pulmonary artery oxygen saturation. However, not only is the outlay for the machine high but each disposable catheter is expensive, about double the cost of a pulmonary artery catheter with thermodilution cardiac output facilities. Intermittent sampling of mixed venous blood from a cheaper venous catheter would therefore be more practical for measuring mixed venous oxygen.

The venous drainage of the right atrium consists of the superior and inferior vena cava which drain separately into the right atrium. The coronary sinus, anterior cardiac veins and the thebesian veins likewise empty into the right atrium. The thebesian veins also drain into the other chambers of the heart.

Blood samples from the above sites have different oxygen tensions, and therefore different oxygen saturations. In theory, there is streaming of blood entering the atrium and the ventricle, which would make oxygen sampling unsuitable from these areas. In order to assess mixed venous oxygen tension blood should therefore be sampled after it has been adequately mixed, for example pulmonary artery blood. To obtain access to pulmonary arterial blood requires, under most circumstances, a flow-directed catheter, pressure transducer and trained staff to monitor the catheter. There are dangers involved in the use of these catheters, and there may be problems in interpreting blood samples from them. If the catheter tip is too distal partially oxygenated blood may be aspirated, giving falsely high pulmonary arterial blood oxygen tensions. It would thus be safer and simpler to measure right atrial blood for oxygen tensions if this correlates with pulmonary arterial blood oxygen tensions.

Three previous studies have shown a good correlation between oxygen saturations of blood from the right atrium and the pulmonary artery, but a fourth showed poor correlation when the catheter tip was near the coronary sinus.

Because the relationship between oxygen saturation and oxygen tension is not linear and the oxygen pressure at 50% haemoglobin saturation (P_50) may change under certain circumstances (acidosis, anaemia, pyrexia), thus changing the above relationship even further, it was decided to investigate the linearity of partial pressure of oxygen from the right atrium (RAPvo_2) and that from the pulmonary artery (Pvo_2).

Materials and methods

Patients admitted to the Medical Intensive Care Unit (which serves as both a coronary and respiratory unit of J. G. Strijdom Hospital) who required pulmonary arterial catheterization were used in the trial. A triple-lumen flow-directed pulmonary artery catheter was inserted under pressure monitoring into the pulmonary artery, always via the superior vena cava. The triple-lumen catheter consists of a lumen at the tip of the catheter, one lumen 30 cm proximal to the tip and one blind lumen for inflating the balloon to wedge the catheter intermittently. The position was regarded as optimal if the following criteria were met: (i) when the balloon was inflated with 1-1.5 ml of air, a wedge tracing was obtained on the monitor; (ii) on a chest radiograph the tip of the catheter was seen to be situated in one of the main pulmonary arteries; and (iii) the pressure reading from the proximal orifice showed a tracing consistent with that of the right atrium.

The position of the proximal orifice was thus in the right atrium or the junction between the right atrium and superior vena cava. Blood was sampled slowly over 2 minutes, with no air bubble contamination from the pulmonary artery lumen or from the proximal lumen of the catheter, after dead space fluid from the catheter had been discarded. Blood gas was determined within 5 minutes of sampling by an ABL 1 machine which is calibrated daily with tonometered blood. Eighteen patients had Fick cardiac output measurements done as well.

Results (Table I)

Fifty simultaneous Pvo_2 and RAPvo_2 determinations were made in 30 different patients. In those patients with Fick cardiac output measurements, cardiac output ranged from 2.18 l/min (Pvo_2 29; RAPvo_2 28) to 17.37 l/min (Pvo_2 46; RAPvo_2 48.5). A paired t-test on the above readings gave t = 2.09 (P = 0.01). The correlation coefficient of Pvo_2 vs. RAPvo_2 was 0.96 ± 0.73. The points are plotted in Fig. 1. The slope of the line is 0.82 with an intercept if extrapolated on the ordinate of 5.93, i.e. RAPvo_2 = 0.82; Pvo_2 + 5.93.

Discussion

An excellent correlation between RAPvo_2 and Pvo_2 has been demonstrated. The correlation is even better if an RAPvo_2 of less than 40 mmHg is taken. It must be noted that this trial was done at an altitude of 1 700 m. The clinical range of mixed venous partial pressure of oxygen (P_O_2) is, in our experience,
of the results were above this level. In a study by orilice in the catheters we used, we found no such low oxygen
levels. Seldom greater than 40 mm, although in the current study one-fifth of the results were above this level. In a study by Barnett-Boyes and Wood,23 blood sampled from a catheter was placed near the coronary sinus ostium. Although we could not identify the exact position of the proximal lumen orifice in the catheters we used, we found no such low oxygen levels.

Once the criteria for the position of the pulmonary arterial catheter, listed under Materials and Methods, were met, dye studies showed that the variation of catheter position was such that the 30 cm proximal orifice of the catheter was placed anywhere between the junction of the superior vena cava and right atrium and 1 cm away from the tricuspid annulus in the right atrium. The study showed that, provided the blood sampling point is at least 1 cm away from the tricuspid annulus, the blood sampled from the right atrium or even from the right atrial/superior vena cava junction correlates well with PVO2. It must be stressed that in all our patients catheters were introduced via the antecubital, internal jugular or subclavian vein; therefore inferior vena cava blood was never sampled. It must also be pointed out that our catheters were not free floating in the right atrium, thus the sampling orifice may have been relatively fixed. Changes in the position of the oxyhaemoglobin dissociation curve did not interfere with the linearity of PVO2 and RAPVO2.

In a recent review article Civetta20 maintains that although the correlation between RAPVO2 and PVO2 may be good, the confidence limits are not, and therefore if individual readings are used in calculations of arterial venous content difference, this leads to inaccurate results. Tahvanainen et al.14 came to the same conclusion even though they found a good correlation between superior vena cava PO2 and true mixed venous PO2. The opposite was stated in an article by Kosnin et al.,11 who showed that superior vena cava specimens could be used in shunt equations with little difference from that obtained when substituting pulmonary artery O2 tensions (PVO2). As there is a good correlation between PVO2 and RAPVO2, the latter can be used for monitoring changes in cardiac output,4,16,17 positive end-expiratory pressure administration,8,11 whole-body tissue perfusion and clinical progress.1,2,13,16 Kasnitz et al.25 have shown (although in a relatively small study) that PVO2 correlated well with increased lactic acid levels and with prognosis. RAPVO2 has also recently been used to monitor the clinical state of myocardial infarcts with good results.1

One of the inaccuracies of PVO2 interpretation, namely partially oxygenated blood from gaseous exchange in the lungs if the catheter tip is too distal,26 is not found when using RAPVO2. The same limitations that apply to PVO2 other than the above, are operative when using RAPVO2.

1. RAPVO2 would reflect whole-body tissue oxygenation and perfusion and not those of individual organs. If hepatic, renal or cerebral oxygenation or perfusion needs to be monitored, more specific tests need to be performed.

2. With some cases of sepsis a falsely high PVO2 is found. A high RAPVO2 would also occur.

3. Histotoxic anoxia causes inability of tissues to utilize the oxygen supplied by the circulation and results in a falsely high PVO2 and similarly high RAPVO2.

In view of our and other investigators’ results13,14,22 that have shown RAPVO2 correlating with PVO2, the former may be used with central venous lines to monitor the patient’s progress. With the newer in vivo oxygen sensors being more widely used, the value and benefits of central venous oxygen monitoring will emerge more clearly than is presently the case. As RAPVO2 is simpler and cheaper to measure, we feel it too has a part to play in the management of the severely ill patient.

The authors thank Mrs A. E. Tolmany and Mrs V. Rex for preparation of the manuscript and Mr J. McDonald for advice on the statistics involved.

REFERENCES

<p>| TABLE I. COMPARISON OF RAPVO2 (mmHg) AND PVO2 (mmHg) (CARDIAC OUTPUTS (/min)) |
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Fig. 1. Graph of RAPVO2 in mmHg v. PVO2 in mmHg. The correlation coefficient (r) is 0.96.
Progressive familial heart block
Part I. Extent of the disease

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Summary

Progressive familial heart block (type I) has been identified in the RSA. Since 1977 many families have been referred for pedigree tracing. The present pro bands of some 9 pedigrees are the descendants of specific children of an immigrant; other genetic diseases appear in these pedigrees. The necessity of identifying, diagnosing and possibly treating the descendants of carriers is emphasized.

Since 1977, when progressive familial heart block (PFHB) was identified in the RSA, a further 40 families have been referred for investigation and identification of this disease. The probands requested the investigation of their family histories because they were aware of sudden deaths in the families, because the death had occurred at a comparatively young age, and because their observation had led to anxiety.

Investigation of these family pedigrees sought to identify new branches of families with PFHB, which could have had a link with the original study. It also sought to establish a possible connection between PFHB and other genetic diseases, to document the progression of heart blocks in the identified individuals (Part II of this study; p. 356), and finally to offer counselling and referral to the affected members of the families whenever necessary.

Patients and methods

South Africa is fortunate in that it has unique documentation on all the immigrants who came to this country in the 17th century. This documentation, classified in the work of De Villiers and Pama and the Dutch Reformed Church records, makes it possible to trace white South African families from the present generation back to the original European immigrants. Such families, at the rate of a new generation every 25 years, can have only 13 generations. Present knowledge of a hereditary disease spread over current generations therefore allows researchers to seek a founder member in the original ancestors. Such work is, however, time-consuming and this article refers to only 9 families in whom full documentation was possible.

Results

Families V, W, R, F, VN

These families were traced back to the same ancestors of D and F as described by Brink and Torrington, namely individuals 3, 4