Reliability of Capillary Blood for the Measurement of \( \text{pO}_2 \) and \( \text{O}_2 \) Saturation*

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The direct measurement of partial pressures of oxygen and carbon dioxide in arterial blood is valuable in both research and in clinical conditions related to cardiac and pulmonary disease. The acid base evaluation by capillary blood and microtechnique for pH, \( \text{pCO}_2 \), base excess and standard bicarbonate has been well established.\(^1\)\(^2\) However, the analysis of \( \text{pO}_2 \) and \( \text{O}_2 \) saturation in infants and children is performed less frequently because of the technical difficulty in obtaining arterial blood. Since serial samples are often desired in evaluating such patients, the volume of blood necessary may become prohibitive and the emotional stress to the patient intolerable.

This study was undertaken in an effort to evaluate capillary and venous blood as an alternative to arterial blood. Samples of peripheral venous, arterial and capillary blood have been taken from 26 patients to date. These determinations were done at the time of cardiac catheterization, and permitted simultaneous sampling from these various sites in children of different ages with left-to-right shunts, right-to-left shunts, and no shunts.

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The \( \text{pO}_2 \) electrode used (Radiometer, Copenhagen, Denmark) is a Clark-type oxygen electrode. It consists of a combined platinum cathode and silver/silver chloride anode placed in an electrolytic solution (phosphate buffer with added KCl to stabilize the reference electrode) behind a polypropylene membrane. A polarizing voltage will diffuse oxygen through the membrane and will be reduced at the platinum electrode. It is capable of giving accurate determinations on as little as 70 \( \mu \text{l} \) of blood, thus making it ideal for this project.

The new oximeter (American Optical Company, Buffalo, New York) was utilized for oxygen saturation. The design and reliability of this modified reflection oximeter (requiring 0.2 ml of whole blood) has recently been reported by Gambino et al.\(^4\)

**Method**

Samples from peripheral venous blood and arterial blood were obtained at the time of the initial cutdown for catheterization. This was usually in the antecubital fossa or femoral areas. The collection of arterialized capillary blood was from a finger

![Graph showing comparison of capillary and arterial \( \text{pO}_2 \) values](image_url)
(older children) or a toe (infants) immediately after leaving the cardiac catheterization laboratory. The hand or foot was first wrapped in a pack with a hot water bath for a period of no more than ten and no less than five minutes with temperatures at 39° to 40° C. After the pack was removed, the finger or heel was pierced with a micro lancet or a No. 11 Bard-Parker scalpel blade, to obtain effective free bleeding, and blood was drawn by means of capillarity into a heparinized micro blood collecting tube. These were used immediately without storing. Special precautions were taken to avoid squeezing the extremity for adequate sampling because of slow capillary flow and no sample with interspersed air bubbles was acceptable.

**RESULTS**

The results were compiled from 26 patients for oxygen tensions, but only 11 so far have been compared for O₂ saturation. As indicated in Table 1, the age range was three days to 15 years, but the majority were five years old and under.

Inspection of Fig. 1 shows the close relationship between capillary and arterial pO₂ that was obtained. The excellent correlation between capillary and arterial O₂ saturation and pO₂ is demonstrated in the dissociation curves of Fig. 2A and B. The relationship between arterial pO₂ and peripheral venous pO₂ does not show the same good relationship (Fig. 3).

To date, statistical data have been obtained to evaluate the reliability of micro (capillary) pO₂ compared to macro (arterial) pO₂ and appear encouraging (Table 2). Although this shows a good relationship, there is still a suggestion of some minimal difference. It was felt that this may have been due to the time delay in moving the patient from the catheterization laboratory to the recovery room where the micro sample was obtained. To eliminate this factor, a micro collection of blood was taken in the previously described method.
and while the sample was being collected a needle was placed in the brachial artery for macro collection. The patient was then given 100 per cent O₂ by mask for three minutes and the procedure repeated. It demonstrated almost identical results (Fig. 4).

**DISCUSSION**

The results of the collection of capillary and arterial samples confirmed previous observations on the reliability of determinations done on properly collected capillary samples. However, previous observations were based on acid base estimations for pH, pCO₂ and SHCO₃. Our studies would indicate similar good results for simple capillary collecting tubes in evaluating pO₂ and O₂ saturation. Arterial samples have been shown to relate well to capillary collection of blood in other studies, but the methods were cumbersome, requiring special collect-

![Comparison of Capillary and Arterial PO₂](image)

**FIGURE 4**

- At room air
- After 3 min. of 100% O₂

It has been felt that collection of samples may be altered greatly if there is exposure to room air, particularly when measuring O₂ tensions. Our studies to date would indicate that in properly prepared and obtained capillary samples in simple heparinized tubes, results are comparable with samples collected simultaneously from direct arterial puncture. At present, comparisons made on peripheral venous collection would indicate that this is not a reliable substitute.

The advantage of properly arterialized capillary blood becomes apparent. Serial collections can be made by a technician with much less discomfort to the patient (of all ages) who must otherwise be confronted with many difficult arterial punctures.

Further observations with the simultaneous technique for identification of patient response with O₂ inhalation is planned. Evaluation of time and storage methods of both capillary and macro samples would also be beneficial in future studies. However, the evaluation to date would indicate the excellent reliability of capillary “arterialized” blood for pO₂ determinations.

**SUMMARY**

The reliability of “arterialized” capillary blood for pO₂ and oxygen saturation was demonstrated. Samples taken simultaneously of capillary and arterial blood on children with both left-to-right and right-to-left shunts showed a close relationship.

The technique for capillary sampling is described and proved simple but effective.

**RESUMEN**

La capacidad de la sangre capilar “arterializada” para la pO₂ y la oxigenación a saturación ha sido bien demostrada. Las muestras tomadas simultáneamente de la sangre capilar y arterial en niños con derivación (shunt) de derecha a izquierda y de izquierda a derecha indistintamente, presentan una estrecha correlación.

Describimos una técnica sencilla, pero efectiva, para la obtención de muestras capilares.
Resumé

Demonstración de la valeur du sang capillaire "artérialisé" pour calculer pO₂ et la saturation en oxygene. Des échantillons pris simultanément du capillaire et du sang artériel chez des enfants ayant à la fois un shunt gauche-droit et un shunt droite-gauche, ont montré une bonne corrélation. La technique pour les échantillons capillaires est décrite et se montre simple mais efficace.

Zusammenfassung


TRACHEOESOPHAGEAL FISTULA AND ESOPHAGEAL ATRESIA

Forty-two infants with tracheoesophageal fistula and/or esophageal atresia were admitted to the University of Illinois Research and Educational Hospitals over a period of 15 years. A primary definitive operative procedure was performed on 34 patients. The mortality rate was 44 per cent for the entire period, being 36 per cent during the past ten years. Analysis of factors effecting survival indicates that associated congenital anomalies, especially congenital heart disease and prematurity, have been the most significant factors responsible for the low survival rate. Patients with insignificant or no associated congenital anomalies had survival rates of 83 and 74 per cent, respectively. Cinefluoroscopy in a patient with tracheoesophageal fistula without atresia proved valuable.

CORONARY CINEANGIOGRAPHY

Examination was made of standard lead III of the electrocardiogram recorded during selective right and left coronary artery injections of diatrizoate sodium (Hypaque-M) 78 per cent in 107 patients. Left coronary artery injection caused the mean frontal plane QRS vector to shift transiently to the left and T wave vector to shift toward the right. Right coronary artery injection caused shifts of the QRS and T wave vectors in the opposite directions. Occlusion of one main coronary artery caused these ECG changes to be minimal or absent. Transient sinus bradycardia was common with injection of either coronary artery. Serious arrhythmias were rare. The electrocardiogram recorded during selective coronary arteriography can give useful information during the procedure itself as well as during the subsequent interpretation of the angigram.

REFERENCES