Use of conjunctival oxygen monitoring in cardiac patients in the emergency unit

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SUMMARY

Conjunctival oxygen monitoring (P_{cjO_2}) measures conjunctival tissue oxygen. It has proved useful in helping to evaluate hypovolemic multiple trauma patients, carotid artery surgery patients, as well as others. Little has been written about its use during medical resuscitations. This report reviews its accident and emergency department use in 13 cardiac arrest/life-threatening cardiac dysrhythmia patients. Nine patients expired and four patients survived. Accident and emergency department P_{cjO_2} values in the group which expired averaged 6.3. Those patients who survived averaged 35.4. Subjects who maintained P_{cjO_2} values below 20 did not survive. Furthermore, P_{cjO_2} values taken within the first 8 min of accident and emergency department resuscitation appear to indicate outcome. Conjunctival oxygen monitoring may be useful in monitoring critically ill cardiac patients in the accident and emergency department.

INTRODUCTION

Conjunctival oxygen measurement has been used experimentally in a variety of clinical situations including trauma (Abraham *et al.*, 1984a), cardiac arrest (Abraham *et al.*, 1984b), atrial flutter (Podolsky *et al.*, 1985) and carotid artery surgery (Shoemaker & Lawner, 1983) to delineate its usefulness in the evaluation of critically ill patients. This study reports the results of conjunctival oxymetry in 13 hemodynamically compromised patients, with specific emphasis on the prediction of patient outcome using this monitoring modality.

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MATERIALS AND METHODS

All adult patients presenting to the Albert Einstein Medical Center, Northern Division, Emergency Department, Philadelphia, PA, USA between October 1984 and December 1985 who had life-threatening arrhythmias or who were undergoing cardiopulmonary resuscitation were eligible for inclusion in this study, with the following exceptions: patients with glass eyes, conjunctivitis or trauma to the eyes or periorbital areas, and those patients for whom a 'do not resuscitate' status was in effect. Those subjects actually included in the study were those who arrived at the accident and emergency (A&E) department when one of the authors (S.P.) or his designee was available to initiate conjunctival oxygen monitoring.

Upon arrival to the A&E department, patients undergoing resuscitation or who appear to be in imminent need of resuscitation are placed in the resuscitation suite, where continuous electrocardiographic monitoring, respiratory and fluid support, surgical equipment and X-ray capability are all readily available. Shortly after their placement in the resuscitation suite, an Orange Medical (Costa Mesa, CA, USA) conjunctival sensor was placed against the right sclera of those patients included in this study. The sensor consists of a miniaturized Clark-type electrode mounted in a ring-shaped ophthalmic conformer made of optical grade polymethacrylate (a material used for contact lenses). The current produced at the electrode by the reduction of diffused oxygen is converted to a digital display by a portable electronic monitor which provides a continuous readout of oxygen tension in mmHg. The sensor is calibrated using a two-point system, and once it is placed against the palpebral conjunctiva, stabilization is completed within 2 min.

The sensor is placed by first gently retracting the upper eyelid and slipping the upper part of the conforming ring under the lid, then retracting the lower lid and sliding the lower arm of the ring under that lid. The sensor is then held gently against the palpebral conjunctiva by the pressure of the eyelids. No corneal contact is made, and vision and eye motion are not restricted.

The digital readout was recorded by the investigator every 30–180 s after an initial 2-min sensor stabilization period. Cardiac rhythm and interventional measures (e.g. defibrillation and intubation) were also recorded, as was the outcome of the resuscitation itself. Interventions and further laboratory tests were utilized according to the conditions and needs of the patients as determined by the leader of the resuscitation team. $P_{\text{c}}\text{O}_2$ measurements were not made available to this person.

Statistical analysis of the data thus obtained was performed using the two-tailed Student's *t*-distribution and the 'four-fold' Chi-square test with Yate's correction.

RESULTS

In the course of the study, 13 subjects were studied. Of these, four survived their initial catastrophic process and nine expired. The results contained herein apply only to initial survival; no attempt at long-term follow-up was made.

Of the nine subjects who expired (Group I), eight presented in asystole; the ninth in ventricular fibrillation. The four subjects who survived (Group II) all presented in ventricular tachycardia. Conjunctival oxygen (PcjO₂) readings in Group I ranged from 0 to 29 (average 6.3) during their first 6 min of recorded monitoring (actually minutes 2 through 8, given the 2 min stabilization period for the sensor), while PcjO₂ readings in Group II ranged from 18 to 66 (average 35.4) in that same time span (see Table 1).

Table 1 Presenting cardiac rhythms, patient outcome, and PcjO₂ measurements in 13 critically ill patients

Patient	Presenting		PcjO ₂	
	Rhythm	Outcome	Range	Average
<i>Group I</i>				
# 1	Asystolic	Expired	8–13	12.2
# 2	Asystolic	Expired	2–29	11.6
# 4	Asystolic	Expired	4–6	4.8
# 6	Asystolic	Expired	1–13	5.5
# 8	Asystolic	Expired	2–12	6.2
# 9	Asystolic	Expired	1–3	1.8
#11	VF	Expired	0–3	1.0
#12	Asystolic	Expired	0–0	0.0
#13	Asystolic	Expired	6–15	8.8
<i>Group II</i>				
# 3	VT	Survived	18–40	27.5
# 5	VT	Survived	26–38	31.3
# 7	VT	Survived	58–66	61.7
#10	VT	Survived	29–33	31.5

Fig. 1. Average PcjO₂ measurements in two groups of critically ill cardiac patients.

Statistical analysis of the data reveals the following: (1) there is a statistically significant difference between the Pc_jO_2 levels reached by Group I and those of Group II (Student's t -distribution, $P < 0.0001$), and (2) subjects who maintain Pc_jO_2 readings below 20 do not survive (Chi-square, four-fold with Yates's correction, $P < 0.01$) (see Fig. 1). However, one Pc_jO_2 reading below 20 in the first 6 min of recording has no significance.

DISCUSSION

This study was undertaken primarily to determine whether or not Pc_jO_2 measurements are useful in ED patients who suffer out-of-hospital cardiac arrest or who present with a life-threatening cardiac dysrhythmia.

As shown in Table 1, nearly all the subjects in Group I were asystolic upon presentation to the ED. In contrast, all of the subjects in Group II presented in ventricular tachycardia. It has long been noted that asystolic patients respond to resuscitative efforts far less often than do patients in ventricular tachycardia or ventricular fibrillation and (Diamond *et al.*, 1977; Iseri *et al.*, 1977; Myerburg *et al.*, 1980; Smith & Bodai, 1985) and these data are consistent with this finding.

Also illustrated in Table 1 are the range and average of Pc_jO_2 measurements in subjects in both groups. It is obvious from this table that those subjects who died had consistently low Pc_jO_2 readings. The authors consider this to be a central finding in this study. In contrast to subjects in Group II who had occasional low readings which immediately rose when their arrhythmias were treated, subjects who died maintained low Pc_jO_2 measurements. The difference between the measurements in Group I and those in Group II is statistically significant, as noted above. This indicated that subjects in Group I came from a population that does not respond to resuscitation, while Group II subjects came from a population that does respond to these efforts. Likewise, the Chi-square test predicts that patients who maintain low Pc_jO_2 measurements will not survive. Figure 1 demonstrates that there was no overlap between the average Pc_jO_2 readings in the two groups.

Survivors were monitored far longer than subjects who died (Group I, av. 16.7 min, Group II, av. 60.8 min.) Data was taken from the first 8 min of monitoring for use in the statistical calculations in this study.

There are other works written relative to our report. In Abraham's study of 11 patients undergoing CPR, it was noted that tissue oxygenation and perfusion changes occurred in patients undergoing CPR, however survival rates in these patients were not discussed (Abraham *et al.*, 1984b). This issue was addressed in our study. In a single case report Abraham & Ehrlich (1984) did record Pc_jO_2 measurements in a patient whose initial rhythm was asystole and appeared to have a Pc_jO_2 of less than 10 mmHg. This patient expired. This was confirmed in the present study (Abraham & Ehrlich, 1984).

Eliastam *et al.* (1977) have suggested that patients should have ACLS discontinued if they do not respond to 30 min or more of ACLS or if they have no ventricular EKG

activity after more than 10 min of ACLS. The present authors' mortality data is supportive of that suggestion. Furthermore, this data suggests that the outcome of ACLS can be prognosticated within the first 8 min of ED resuscitation by the use of conjunctival oxygen monitoring.

It must be reiterated that this study involved resuscitation of patients brought to the ED after suffering an out-of-hospital cardiac arrest or who had life-threatening cardiac dysrhythmias. All data presented from this data are relevant only to this type of patient, and should not be extended to those patients experiencing cardiac arrest while inpatients on wards or in intensive care units. Moreover, this study considered very small groups, and no attempt was made to determine the length of resuscitation time prior to the subjects' arrival in the ED. It is suggested that further study of conjunctival oxygen monitoring with larger groups than this and with attention to the length of resuscitation measures in the out-of-hospital setting would be helpful in the ascertainment of when and for how long ACLS should be employed.

In the current environment of limited physical resources and curtailed budgets, guidelines are needed for allocation of these physical and monetary reserves. The cost of resuscitation attempts varies depending upon the hospital and the lengths to which the rescuers go (e.g. intubation, temporary pacemakers and defibrillation). Obviously, the longer the attempt goes on, the higher its potential cost, not only in money but in terms of availability of physicians and other personnel to care for other—possibly more salvageable—patients.

The present authors have presented data which suggests that Pc_jO_2 measurements within the first 8 min of ACLS in the ED can indicate the outcome of resuscitation. From this data, they believe that conjunctival oxygen monitoring is a useful additional parameter which, in conjunction with traditional methods, can help to determine when to discontinue resuscitation in a patient who has suffered an out-of-hospital cardiac arrest.

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