

THE EFFECTS OF CHEST PHYSIOTHERAPY AND TRACHEOBRONCHIAL SUCTIONING ON $tcPO_2$ IN MECHANICALLY VENTILATED NEWBORN INFANTS

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SUMMARY

This research project was planned to investigate the problem of hypoxaemia which occurred in the neonatal age group as a result of chest physiotherapy. The study was conducted on mechanically ventilated infants under the age of one month. Nine studies were carried out, these being divided into 3 categories: (1) The assessment studies, which were planned to investigate the effect of the existing method of chest physiotherapy to $tcPO_2$ (transcutaneous oxygen tension). From the results it was clear that there was need for revision in the existing method. (2) The preliminary studies were designed to establish the optimum levels in the following components of chest physiotherapy: the correct oxygen concentration for hyperventilation during chest physiotherapy; the correct suction pressure for tracheobronchial suctioning in the neonate; the most suitable manual ventilation system for the neonate. (3) The findings of the preliminary studies were used to formulate an upgraded method. This method was tested against the new method which involved the use of a mechanical vibrator. It was found that excessive handling of the infant exposed it to significant falls in $tcPO_2$.

INTRODUCTION

The management of the newborn infant with respiratory distress syndrome is one of the more striking success stories of modern perinatal care over the past two decades. The improved care of the ill neonate is largely due to the advances in the understanding of the aetiology and pathogenesis of diseases that challenge this age group.

The introduction of mechanical ventilation has also assisted in lowering the mortality rates in this age group. However, the application of this has given rise to many problems. It has been found that the success of mechanical ventilation in this age group depends largely on the maintenance of clear airways.

Intubated newborn infants require special care, including intensive chest physiotherapy and tracheobronchial suctioning to keep the airways patent. Although the need for this form of therapy is well recognised, it is now a well-documented fact that in the neonate chest physiotherapy has a side effect in the form of a resultant state of temporary hypoxaemia (Holloway *et al*, 1966 and 1969; Gregory, 1974; Dangman *et al*, 1976; Fox *et al*, 1978; Coradello *et al*, 1979 and Simbruner *et al*, 1981.) However, Holloway *et al* (1969) showed that hyperventilation in the form of intermittent bag ventilation with 100 per cent oxygen or with an oxygen-enriched gas could prevent a critical drop in PO_2 during therapy, thereby minimising the effect of hypoxaemia. Subsequently hyperventilation has become a routine practice in infants during the receipt of chest physiotherapy.

OPSOMMING

Hierdie navorsingsprojek is beplan om die probleem van hipoksie as gevolg van fisioterapie in die neonatale ouderdomsgroep, te ondersoek. Die ondersoek is gedoen op suigeling, onder die ouderdom van een maand, wat meganiese geventileer is. Nege studies is gedoen, verdeel in 3 kategorieë: (1) Evalueeringsstudies, wat beplan is om die effek van die huidige borskasfisioterapie metode op $tcPO_2$ (transkutane suurstof spanning) te ondersoek. Van die resultate was dit duidelik dat die huidige metode hersien moes word. (2) Voorlopige studies is ontwerp om die optimum vlakke in die volgende komponente van borskasfisioterapie vas te stel: die korrekte suurstofkonsentrasie vir hiperventilasie gedurende borskasfisioterapie; die korrekte suigingsdruk vir tracheobronchiale suiging vir die pasgeborene; die mees geskikte ventilasie sisteem vir die pasgeborene. (3) Die bevindings van die voorlopige studies is gebruik om 'n beter metode te formuleer. Hierdie metode is vergelyk met die nuwe metode waar 'n meganiese vibrator gebruik word. Daar is gevind dat oormatige hantering van die suigeling hom blootstel aan aansienlike daling in $tcPO_2$.

THE PURPOSE OF THIS STUDY

This study was undertaken to evaluate every component of chest physiotherapy as applied to the neonate at King Edward VIII Hospital in Durban (South Africa). This was done with the intention of isolating the cause of hypoxaemia.

METHOD

Patient population

A total of 134 patients were used in this study. They were all infants under the age of one month. Forty five were diagnosed as neonatal respiratory distress syndrome, 86 as tetanus neonatorum and 3 as post-operative respiratory complications.

Measuring Index

It is now widely accepted that the measurement of blood gases is one of the most reliable methods of assessing respiratory function. In these studies transcutaneous oxygen monitoring was used to assess the effect of therapy. This is a non-invasive method and has proved very reliable in the neonatal age group.

CHEST PHYSIOTHERAPY

This consisted of:

- Intermittent Positive Pressure Manual Ventilation (I.P.P.M.V.) with the aid of a locally made mini rubber bag.
- Manual vibrations applied to the chest.
- Tracheobronchial suctioning.

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THE STUDIES

Nine studies were conducted over a period of six months. These were divided into 3 categories:

- Assessment studies
- Preliminary studies
- Final study

The *assessment studies* were designed to investigate the effect of the existing method of chest physiotherapy on transcutaneous oxygen tension (tcPO₂).

One of the assessment studies investigating the combined effect of chest physiotherapy and suctioning showed that this form of therapy caused a fall in tcPO₂ in every infant used in the trial. The mean fall was 37 mmHg in the 13 infants studied. The fall in tcPO₂ lasted up to 45 minutes before pre-physiotherapy levels were achieved.

On examining the results of all the assessment studies it was clear that there was a need for revision in the existing method of chest physiotherapy.

The *preliminary studies* were designed to provide information regarding the optimum and safe levels in the various components of neonatal chest physiotherapy. For example, one study was planned to investigate the routine use of 100 per cent oxygen during chest physiotherapy. The results of this study indicated that it was totally unnecessary to expose every infant to 100 per cent oxygen during physiotherapy. This was highly significant because the dangers of oxygen toxicity is a very real problem.

It was now possible to provide some guidelines as to the percentage of oxygen requirement in every infant requiring therapy. Only those infants with resting tcPO₂ below 100 mmHg required 100 per cent oxygen whereas infants with tcPO₂ levels over 120 mmHg could easily be managed with 60 per cent oxygen during therapy.

Another preliminary study was designed to determine the safe suction pressures that could be applied to the neonatal airways. Three pressure levels were tested, -350 mmHg, -250 mmHg, -150 mmHg. It was found that there was considerable disturbance in oxygenation and that the hypoxaemia could not be reversed even with 100 per cent oxygen if the negative suction pressure was not regulated within safe levels. High suction pressures (over -150 mmHg) caused a marked drop in tcPO. On the basis of resulting tcPO₂ changes, a suction pressure of not more than -150 mmHg was recommended when suctioning neonatal airways. The last set of preliminary studies were planned to

determine the most effective manual bag ventilation system for the neonate. In this study 3 bags were compared:

- The conventional locally made mini bag, the size of a toy balloon.
- The Samson Neonatal Resuscitation Bag.
- The Paediatric Ambu Bag.

Two important features were considered when determining the most suitable bag ventilation system, that is, the inspiratory pressures generated by the system and the tcPO₂ levels achieved. The Paediatric Ambu Bag proved to be the safest when the above factors were considered.

The outcome of the *preliminary studies* was a drastic revision in the existing method of chest physiotherapy as applied to the neonate with respiratory distress. The findings provided the much-needed information to formulate a well-graded method of chest physiotherapy which was best suited for the mechanically ventilated neonate.

When the efficacy of this upgraded method was tested it was found that it was still not possible to eradicate the incidence of hypoxaemia. Nevertheless the drop in tcPO₂ resulting from the upgraded method was far smaller than the fall in tcPO₂ resulting from the conventional method.

The combined effect of chest physiotherapy and suctioning resulting from the upgraded method caused a mean fall of 16 mmHg in a study which involved 21 infants.

THE FINAL STUDY

This was a comparative study to investigate tcPO₂ changes brought about by two different methods of chest physiotherapy in the neonate. Twenty-one mechanically ventilated infants were studied, diagnoses as shown in Table I.

Method 'A'

This consisted of a routine clinical assessment carried out for each infant prior to therapy. Only those who were clinically stable were used for the study. TcPO₂ was monitored during the course of the entire study with measurements being recorded before and after physiotherapy. The pre-therapy measurement was made while the infant was at rest. Subsequently the infant was transferred to the manual ventilation system using the Mini Ambu Bag. The cot was then tilted to effect drainage of the affected areas of the lung. This was followed by manual vibrations on the chest alternated with bag ventilation. After

TABLE I
DIAGNOSIS OF PATIENTS

Diagnosis	Paralysed	Without Paralysis	Total Number
Severe Neonatal Tetanus	11	8	19
Neonatal Respiratory Distress Syndrome		1	1
Neonatal Post-Operative Complication		1	1

TABLE II
COMPARISON OF METHOD A AND B: PRE- AND POST-PHYSIOTHERAPY tcPO₂ (MEAN AND S.D.): MEAN OF THE DIFFERENCES OF tcPO₂ AND STABILISATION TIME (MEAN AND S.D.)

Indices	Method A	Method B	P Value	Mann-Whitney U-Test 'Z' Value
Pre-Physiotherapy tcPO ₂ (mmHg)	91 ± 37	91 ± 36	0.05	0.1384
Post-Physiotherapy tcPO ₂ (mmHg)	76 ± 39	94 ± 39	0.05	1.6477
Post-Minus Pre-Physiotherapy tcPO ₂ (mmHg)	-16 ± 20	3 ± 15	0.001	3.4463
Stabilisation Time (Minutes)	16 ± 15	8 ± 8	0.01	2.704

vibrating the chest for about 2 minutes, tracheobronchial suctioning was performed, using the standard suctioning technique with a suction pressure of -150 millimetres of mercury. Chest physiotherapy and suctioning were carried out for ten minutes, during which time 4 to 6 suctionings were carried out.

On completion, the bag ventilation was kept on for about 20 seconds after which the infant was returned to the ventilator. A tcPO_2 measurement was recorded just before this was done. Thereafter, the tcPO_2 was observed carefully to note the time taken for it to return to pre-physiotherapy level.

Method 'B'

The second physiotherapy method was carried out after the infant had rested for at least two hours. As far as possible Method 'A' was done in the morning and Method 'B' in the early afternoon. Method 'B' involved chest physiotherapy being done while the infant remained on the ventilator.

tcPO_2 measurement was made prior to therapy and then the oxygen concentration was increased according to the clinical demands of the infant. This was done by noting the resting tcPO_2 and increasing oxygen concentration as recommended by the preliminary study on ideal FIO_2 . The cot was then tilted to drain a specific area pre-determined by the clinical assessment.

Thereafter, a battery-operated mini vibrator was applied over the chest of the neonate for about 2 minutes after which the airways were suctioned by disconnecting the infant from the ventilator. Physiotherapy continued for about ten minutes during which 4 to 6 suctionings were carried out with mechanical vibrations being applied in between each suction. On completion, tcPO_2 measurement was recorded. The infant was kept on the increased oxygen for about 20 seconds before resting FIO_2 was restored. As in Method 'A' the time taken to reach pre-physiotherapy tcPO_2 was noted.

RESULTS

There was no comparison in the mean pre-physiotherapy tcPO_2 values between Method A and B. This was also the case when the mean post-physiotherapy tcPO_2 of Method A and B were compared. When method A and B were compared, the mean of the differences between post-physiotherapy tcPO_2 and pre-physiotherapy tcPO_2 were found to be highly significant. The stabilisation time between Method A and B was also significantly different.

DISCUSSION

In Table II, although the mean post-physiotherapy tcPO_2 of Method A fell quite markedly, this was not significantly different from the post-physiotherapy level of Method B. However, when the difference in tcPO_2 produced by each method was averaged and compared, the fall in tcPO_2 caused by Method A was seen to be significantly different from the change caused by Method B ($p = 0,001$). Further, the stabilisation time after Method B was half that of Method A ($p = 0,01$).

These results show that Method B is superior to Method A in that it did not lead to potentially dangerous hypoxaemia and the infants recovered from the procedure more rapidly. Method A was, therefore, carefully planned to cause minimum exertion on the neonate during chest physiotherapy. However, this study shows that even with careful consideration of every detail in the physiotherapy schedule, a fall in tcPO_2 was unavoidable. Long *et al* (1980)

and Speidel *et al* (1978) have shown that excessive handling of the infant exposes it to significant falls in tcPO_2 . Curran *et al* (1979), on the other hand, have shown improvements in the oxygenation of infants while using a modified electric tooth-brush to vibrate the chest. It would, therefore, seem that the present bagging technique and manual vibrations may be largely responsible for the drop in tcPO_2 . Method B, on the other hand, allowed the infant to remain on the ventilator and the mechanical vibrator minimised handling.

This study shows Method B exerts almost no stress on the infant, but it does not follow that the mechanical vibrator will always move secretions as well as vibration by hand. However, the fact that pre-physiotherapy tcPO_2 levels were achieved so quickly after the procedure suggests that secretions were efficiently shifted.

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INSTRUCTIONS TO PHYSIOTHERAPISTS WHO WISH TO OBTAIN EMPLOYMENT IN SOUTH AFRICA

All physiotherapists wishing to obtain employment in the Republic of South Africa need to register with: The Professional Board for Physiotherapy, The South African Medical and Dental Council, P.O. Box 205, Pretoria, 0001. The registration fee is R10 and thereafter R15 per annum. The necessary forms may be obtained upon application to the Registrar. A certified (by notary public) copy of qualifications together with full details of training must be submitted with the application. If necessary, an official translation into English should be included. Registration with the Council is compulsory by law for all physiotherapists.