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Research Article

ARTERIAL TO END TIDAL CARBON DIOXIDE DIFFERENCE DURING GENERAL ANESTHESIA FOR NEUROSURGICAL PROCEDURES: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

ETCo2 measures partial pressure of carbon dioxide at the end of expiration with the help of non-invasive capnography.PaCo2 is defined as the partial pressure of arterial Co2 and measured by using a blood gas analyzer. In all neurosurgical procedures, anesthetist need to continuously monitor PaCo2 which is both invasive and cumbersome. Hence it was proposed whether ETCo2 measurement could be a reliable alternative instead of PaCo2 during general anesthesia and prospective observational study was done in 62 patients in our institution. The results showed there was correlation between ETCo2 and PaCo2 with P(a-ET) Co2 to be between 2-6 but the difference was more pronounced in surgery lasting for more than 2 hours.

INTRODUCTION

ETCo2 means partial pressure of carbon dioxide at the end of expiration. Capnography measures end tidal carbon dioxide (ETCo2) and helps in the monitoring of respiratory function of patients during anaesthesia and also in the intensive care units. PaCo2 is the partial pressure of carbon dioxide as it is measured by arterial blood gas analysis. Intracranial pressure dynamics changes according to the PaCo2 level. For example, high PaCo2 will cause increase in brain blood volume and hence raise of intracranial pressure there by reducing the cerebral perfusion. During neurosurgical anaesthesia, hyperventilation is frequently used to bring down the intracranial pressure before making the dural incision. But if the hyperventilation lowers PaCo2 to 20mm Hg or less, there could also be risk of regional cerebral tissue hypoxia. Hence frequent close monitoring of PaCo2 is ideal in neurosurgical anaesthesia which could be costly and cumbersome. (Russel *et al* 1995)

ETCo2 correlates well with arterial blood gas carbon dioxide tension PaCo2 with reported difference between them of about 2 to 5 mm Hg in normal adult persons with latter being lower. It is proposed that ETCo2 monitoring could be used as cost effective noninvasive alternative practical way to assist in the adjustment of hyperventilation (Mackersie *et al* 1990). But there is no consensus on reliability of capnography to achieve the desirable level of PaCo2 as there has been no study with reliable data with regards to expected gradient between ETCo2 and PaCo2. The aim of this study was to find out the relationship between PaCo2 and ETCo2 measured during anaesthesia for neurosurgical procedures to find if ETCo2 could reliably estimate PaCo2 during neurosurgical general anaesthesia. (Kerr *et al* 1996)

METHODS AND MATERIALS

This was a prospective observational study conducted by the department of anaesthesia in Dr.D.Y. Patil Medical college, Pimpri, Pune, India for period of 6 months from November 2021 after obtaining the institutional ethical committee approval.

A thorough preanesthetic checkup was done which included history of presenting illness, past illness, surgical, medical and drug history, general and systemic examination and routine and specific investigations depending on the age and complaints of the patients.

The study was conducted in 62consecutive patients of both sex in age group of 18-60 years who were ASA Grade 1/II and posted for various neurosurgical procedures under General Anaesthesia in supine position. Informed written consent was obtained from all patients

Following types of patients were excluded for the study namely heavy smokers, ASA Grade > 2, Pregnant women, obese patients, patients with severe cardiovascular disease and suspected difficult airway.

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All patients were kept nil per oral for at least 6 hours prior to surgery. After entering into operation theatre, vital sign monitors were attached to the patient and baseline NIBP, heart rate, SpO_2, $ETCO_2$ and respiratory rate were measured.

Radial artery cannulation was done via ulnar artery after performance of the Allen test to evaluate adequate collateral circulation to the hand. Preoperative sample of arterial blood was collected before induction in a preheparinised 2ml syringe anaerobically, by standard technique and sample was tested for arterial blood gases.

Patients then received preoxygenation with 100% Oxygen for 3 minutes Patients were induced with injection glycopyrrolate bromide 0.004mg/kg, injection fentanyl citrate 2mcg/kg followed by injection Propofol 2mg/kg. Intubation was performed with appropriately sized portex cuffed endotracheal tube after administration of injection succinylcholine 1.5mg/kg. Intermittent positive pressure ventilation was instituted using a volume-controlled mode with a tidal volume of 7-10 ml.kg-1and a respiratory rate of 10-12 breaths per minute. Anaesthesia was maintained with isoflurane in 50% oxygen and 50% air with intermittent bolus doses of injection vecuronium bromide.

Arterial blood samples were collected and sent for Pa Co_2 in the following time periods.

- 10 min after induction
- After craniotomy but before dural incision
- 1 hour after dural incision
- At the start of dural closure
- 10 min before extubation

ETCo2 reading were also be noted during the same five time periods.

Additional analyses of arterial blood gases were performed at the discretion of the attending anesthesiologist when clinically indicated

The $PaCO_2$was measured from arterial blood sample using the blood gases analyser (ABL Radiometer Copenhagen) and corrected to a temperature of 37º C. The $ETCO_2$was recorded simultaneously at the time of each arterial blood gas sampling using a side-stream capnometer (capnometry module, Kion, M-CAIOV.01). The P(a-ET) CO2 was calculated for each arterial blood gas sample.

Heart rate, blood pressure, respiratory rate, tidal volume, peak inspiratory pressure and PaO2 were also recorded at each sampling time.

Data were initially analyzed using Pearson's Correlation to see the relationship between $PaCO_2$ and $ETCO_2$ at different stages of the operation.

P value of < 0.05 was considered significant.

RESULTS

There were total of 62 neurosurgical patients operated during the study period, 35 were male and 27 were female with mean age of 38 (SD 13.2).

Table 1 shows the vital signs and ventilation settings in the study group and they were found to be comparable. Only the patients who had neurosurgical procedures under General anaesthesia in supine position were included in the study and they are divided into 2 groups for subgroup analysis of difference between PaCo2 and ETCo2.

- Group 1: Duration of surgery up to 120 minutes
- Group 2: Duration of surgery between 121 to 240 minutes

Table 2 shows the overall difference between PaCo2 and ETCo2 at 5 different time zones namely

- T0: Baseline
- T1: After Induction
- T2: Before Dural incision
- T3: After Dural Incision
- T4: At Dural closure
- T5: Before Extubation

Figure 1&2 show the bar charts which clearly showed that there was significant difference of Pa (Et Co2) between Group 1 and Group 2.The difference was more pronounced in Group 2 as shown in the chart.

DISCUSSION

Periodic measurement of arterial blood gas for PaCo2 is the ideal way to monitor any changes in Co2. But it is very cumbersome, rather expensive and needs to be repeated several times during any prolonged surgery. Moreover, it is also invasive and won't help the anesthetists where they need continuous measurement of PaCo2. Nowadays several of the anesthetists rather depend on ETCo2 to guess the PaCo2 during craniotomy in order to curtail repeated arterial blood samplings. But the ability of ETco2 to forecast the direction of changes in PaCo2 is doubtful as the literature showed conflicting results.

Table 1 Vital signs and ventilation settings in the study group at various time periods (T0-T5)

Patient Parameter	Unit	Base line (T0)		After induction (T1)		Before Dural incision (T2)		After Dural Incision (T3)		At Dural Closure (T4)		Before Extubation (T5)	
		Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Heart rate	beat/min	92	12	91	3	97	3	100	6	92	1	93	3
Mean arterial Pressure	mm/Hg	79	3	81	2	76	1	74	1	76	1	79	2
Respiratory rate	breath-min	14	1	14	1	14	1	14	1	14	1	14	1
Expired Tidal volume	ml	473	19	473	19	473	179	473	19	473	19	473	19
Peak inspiratory pressure	mm/Hg	19	1	18	0.3	21	1	22	1	20	0	21	1
Pao2		91	2	98	4	99	3	97	0.3	136	11	138	6

Table 2 Overall difference between PaCo2 and ETCo2 at 5 different time zones (T0-T5)

	Base line (T0)		After induction (T1)		Before Dural incision (T2)		After Dural Incision T3		At Dural Closure T4		Before Extubation (T5)	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mea n	Standard deviation
Pa Co2	39	0.6	38	0.5	39	0.9	39	0.7	41	0.9	41	0.8
Et Co2	36	0.7	34	0.5	35	1	35	1	35	1	35	0.8
Pa (Et Co2)	2	0.6	4	0.5	4	0.4	3	0.7	6	1.4	6	1.2

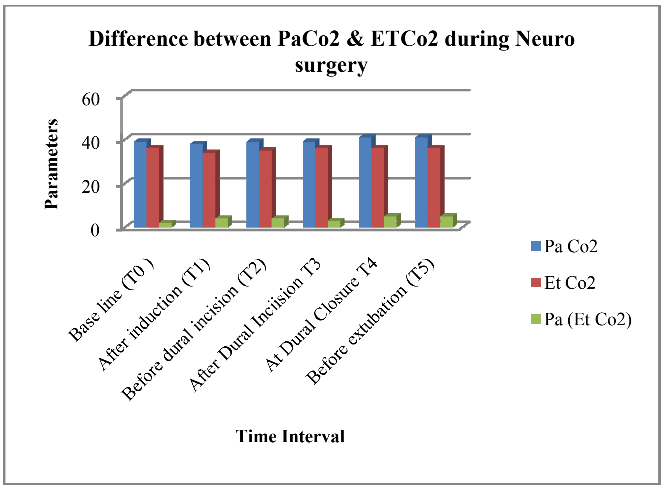

Figure 1 Difference between PaCo2 & ETCo2 during Neuro Surgery lasting up to 120 minutes (Group 1)

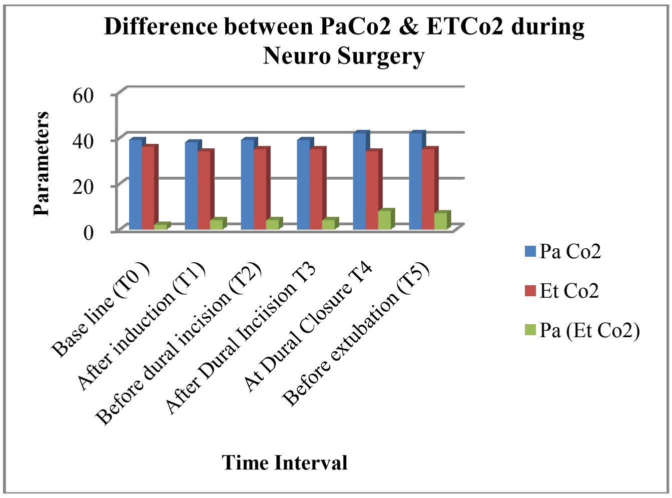

Figure 2 Difference between PaCo2 & ETCo2 during Neuro Surgery lasting Between 120 and 240 minutes (Group 2)

The difference in values of ETCo2 and PaCo2 could be explained by various factors namely, dead space, ventilation/perfusion mismatch, equipment calibration, main stream or side stream capnometry, positioning of patient and room temperature etc.

In our study, the values of ETCo2 and PaCo2 were found to be showing significant correlation during neurosurgical procedures. PaCo2 was found to be always higher when compared to ETCo2 and there was no difference that went in opposite directions. These findings were opposite to what was noted by Russell *et al* during craniotomy (RussellGB *et al* 1990). In our study the correlation of PaCo2 with ETCo2 was significant at various time period during surgery.

Contrary to our observations, Grainier reported that P(a-ET) Co2 was unstable over time when the procedure took more than 3 hours.

During craniotomies, Russell *et al* find P(a-ET) Co2 to 7.2+/- 3.3 mm Hg. He also has noted P(a-ET) Co2 to be 5.47+/- 5.51mm Hg in post cardiac surgery and 6.9+/- 4.4mm Hg in mechanically ventilated neuro intensive care patients. It would be hard to compare these results which are higher compared with the results noted in our study. Instability of intra operative cardiac and pulmonary status could explain such variations.

There are several other papers showing such inconsistent results. The study by Shankar *et al* has shown P(a-ET) Co2 to be 1.9 to 2.4 mmHg during laparoscopic surgery in various terms of pregnancy (Shanker K B *et al* 2000). Rudolph *et al* has shown P(a-ET) Co2 to be 5.5 to 6.9 mm Hg at different phases during early recovery from general anaesthesia (Rudolph F *et al* 1998) In conclusion, we recommend blood gas measurement of PaCo2 along with ETCo2. More over ABG also helps to measure electrolytes, lactate and glucose.

We have noted good correlation between values of PaCo2 and ETCo2 during any neurosurgical procedure in our present study.

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