Original Article

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A Study of Capnography Monitoring During Monitored Anaesthesia Care (MAC)

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Abstract

Background: MAC alone or with local anaesthesia accounts for a relatively high percentage of anaesthesia services now a days. Capnography is a non-invasive monitoring device that closely approximates the arterial carbon dioxide (CO2) levels and thus the ventilatory status of the patients. Objectives were to detect adverse respiratory events by observing the trend in respiratory rate (RR), EtCO2 value, SpO2 value and found association between them. **Subjects and Methods:** Total 60 patients of age 14-65 years of either sex posted for elective procedures carried out under MAC were included in this study. The study investigator (who did not participate in the patient care) was present throughout each procedure and recorded all the data. The sedation provider was blinded to the capnography data throughout the procedure. At any time during the procedure if SpO2 dropped to ≤ 90% or RR ≤8 breaths/min or EtCO2 ≥45 mm Hg, it was considered as respiratory depression and absence of EtCO2 waveform for ≥15 seconds was considered as apnoea. During the study whenever EtCO2 value was ≥60 mm Hg or respiratory rate dropped to ≤6 breaths/min, the study investigator had informed to the sedation provider for timely intervention. **Results:** Main anaesthetic agent used in the study was Inj. Propofol with average dose 1.7 mg/kg and Inj. ketamine 1mg/kg which is safe dose for sedation. Out of 60 patients of the study, total 27 patients (45%) fulfilled either of the pre-defined RD criteria along with apnoea episodes in study. Out of these 27 patients, apnoea (absence of EtCO2 waveform) episodes were detected only by the capnography in 6 (10%) patients. There was total 8 episodes of apnoea in this study, 4 were of < 15 seconds duration and 4 episodes were of ≥ 15 seconds duration in whom the sedation provider was informed by the study investigator for the safety of patients. When we correlated all the 3 parameters, SpO2 detected RD in 22 patients within 20 minutes of starting procedures. Whereas RR and EtCO2 detected RD in 5 and 7 patients respectively either alone or with other parameters. Out of those 27 patients total 25 required interventions. While in rest 33 patients without respiratory events (RE), 11 patients required intervention. When we compared interventions in patients with RE and without RE, p value was <0.001, hence, RE patients required more interventions compared to non-RE patients. **Conclusion:** Though, the value of capnography in monitoring ventilation in patient undergoing procedure under sedation is well appreciated, we could identify few cases of respiratory depression by sole capnography as compared to pulse oximetry. Also, the anaesthesiologists providing sedation were vigilant and able to provide timely intervention in study. Thus, capnography cannot replace clinical observation methods and pulse oximetry in identifying respiratory events. But its value cannot be neglected also, as capnography serves as a warning monitoring tool by instantly drawing anaesthesiologist's attention.

Keywords: Monitored Anaesthesia Care (MAC), Respiratory Rate (RR), End Tidal Carbon Dioxide ($EtCO_2$), Oxygen Saturation (SpO2), Ramsey Sedation Score (RSS), Respiratory Event (RE)

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Introduction

Recently there has been increase in procedures carried out under Monitored anaesthesia care (MAC). Monitored anaesthesia care has been described as a specific anaesthesia service for diagnostic or therapeutic procedures performed under local anaesthesia along with sedation and analgesia titrated to a level that maintains airway reflexes and spontaneous breathing according to the latest American Society of Anaesthesiologists (ASA) update in 2018.[1] MAC alone or with local anaesthesia accounts for a relatively high percentage of anaesthesia services now a days.

For most of the MAC procedures, moderate sedation is preferable. However, the line of demarcation between moderate sedation and general anaesthesia is very thin. Also, the requirement of level of sedation may vary from individual to individual, hence sedative agents need to be individualized. A variety of anaesthetic agents are used to provide MAC sedation, however most of the anaesthetic agents depresses the cardio-respiratory function to a significant extent. This is undesirable for the patient as well as for the surgeon. In addition, it increases the anxiety & stress level of the anesthesiologist to manage the patients

Pulse oximetry is a non-invasive method for monitoring a person's oxygen saturation (SpO_2). Though its reading of peripheral oxygen saturation (SpO_2) is not always identical to the more desirable reading of arterial oxygen saturation

(SaO_2), it is particularly convenient for non-invasive continuous measurement of blood oxygen saturation in any setting including intensive care units, operation theatre, post-anaesthesia recovery room, emergency and hospital ward settings, pilots in unpressurized aircraft and determining the need for supplemental oxygen.[2,3]

Ventilation monitoring by clinical observation is a routine practice during procedural sedation. However, sometimes it is difficult to observe when the patient is surgically draped. However, evidence suggests that apnoea or hypoventilation goes undetected with these methods. Also, pre-treatment with O2 can decrease the usefulness of pulse oximetry and mask hypoventilation, delaying the appreciation of over sedation.[4,5,6]

In the operating room end tidal carbon dioxide (EtCO2) monitoring is the standard practice for ventilation monitoring in intubated patients. Capnography is a non-invasive monitoring device that closely approximates the arterial carbon dioxide (CO2) levels and thus the ventilatory status of the patients.[2,3] In majority of cases respiratory obstruction occurs well before the onset of hypoxia. So, respiratory system monitoring is essential to enable corrective measures before the occurrence of hypoxia. One of the greatest assets of capnography is that it can identify situation that can potentially results in hypoxia.[7] The use of capnography is recommended as a standard for moderate or deep sedation by the American Society of Anesthesiologists & for deep sedation by the Canadian Anesthesiologist Society.[1] Review of literatures suggest that now a days increase incidence of adverse events are there in patients receiving procedural sedation. Thus, the providers with access to capnography were able to provide timely intervention.[10,11,12,13]

Aim of the study was to assess the usefulness of capnography during monitored anaesthesia care (MAC) sedation. Along with it primary objectives were to detect adverse respiratory events by observing the trend in respiratory rate (RR), trend in EtCO2 value, trend in SpO2 value and secondary objectives were to found association between pulse oximetry and capnography to detect respiratory events, incidence of airway interventions, patient's & surgeon's satisfaction to the provided sedation.

Subjects and Methods

The study proposal was submitted to the institutional ethical committee and after the approval from institutional ethical committee, the study was started. A prospective observational study was undertaken in tertiary care hospital over a period of one-year (from April 2018 to March 2019) in patients undergoing elective monitored anaesthesia care (MAC) procedures. Total sixty number of participants were recruited for the study.

All participant's pre-anesthetic check-up was done a day before surgery. To rule out major illness detailed history was taken and systemic examination was done. Routine investigations like Haemoglobin, random blood sugar, renal function test, electrocardiogram was done. Age between 14 to 65 years of either sex, ASA class I, II and III patients, posted for elective MAC procedures were included in study. Patients with history of obstructive sleep apnoea/ BMI ≥35kg/m2, patients with airway anomalies, drug allergy, asthma patients or patients with respiratory distress. patient who was intolerant to nasal cannula, patient with hemodynamic instability, severe trauma with active bleeding, depressed mental status and patient's refusal were excluded from study.

All the participants and their relatives were explained in detail about the study and written informed consent was taken. In case of minor, consent of participant's parent was taken. Pre-operatively, vitals like temperature, pulse, blood-pressure (BP), respiratory rate (RR) were taken. After inserting intravenous cannula to the patient, premedication was given according to the choice of sedation provider. After that patient was shifted to the operation theatre and ECG, pulse oximetry, non-invasive blood pressure cuff (NIBP) was attached to the patient. Nasal EtCO2(end-tidal carbon-dioxide) cannula which was connected to the stand alone capnometer (by Emco Meditek private limited) was attached to the patient and secured.

The study investigator (who did not participate in the patient care) was present throughout each procedure and recorded all the data. The study investigator had also ensured that all monitoring equipments were in the working condition.

Baseline pulse and blood-pressure were recorded and then were noted at 5 minutes interval throughout the procedure. Oxygen saturation (SpO_2), RR and $EtCO_2$ values were noted at baseline and then they were monitored continuously. Sedation provider (who was involved in patient care) had administered drugs according to his/her choice to maintain RSS Score = 3 (RSS=Ramsey sedation scale). The sedation provider was blinded to the capnography data throughout the procedure. Oxygen (O_2) was administered as per the discretion of the sedation provider. The sedation provider monitored the patient clinically and was free to intervene according to his/her own clinical judgment. All the interventions done by the sedation provider were recorded and analysed by the study investigator. At the end of the procedure, total dose of sedative agents used was noted. Any associated adverse event had also been noted along with its treatment.

At any time during the procedure if SpO_2 dropped to ≤ 90% or RR ≤8 breaths/minutes or $EtCO_2$ ≥45 mm Hg, it was considered as respiratory depression and absence of $EtCO_2$ waveform for ≥15 seconds was considered as apnoea. During the study whenever $EtCO_2$ value was ≥60 mm Hg or respiratory rate dropped to ≤6 breaths per minute, the study investigator had informed to the sedation provider for timely intervention.

Before shifting the patient to the recovery room, surgeon's satisfaction score was noted according to the Likert's scale (1-7). At the end of the procedure and after complete recovery, patient was shifted to the recovery room and was monitored for an hour. Before shifting the patient to the ward, overall patient's satisfaction score was noted accordingly to the Likert's scale (1-7).

Modified Ramsey Sedation Scale grades as 1. Anxious, Agitated, Restless, 2. Cooperative, Oriented, Tranquil, 3. Responds to commands only, 4. Brisk response to light glabellar tap or loud noise, 5. Sluggish response to light glabellar tap or loud noise, 6. No Response and Acceptable

scale was 5-7. Patient and Surgeon satisfaction scale (Likert Scale) grades as 1. Extremely dissatisfied, 2. Dissatisfied, 3. Somewhat dissatisfied, 4. Undecided, 5. Somewhat satisfied,6. Satisfied,7. Extremely satisfied was documented.

Statistical Analysis:

At the end of the study, data was entered in Microsoft excel sheet. The statistical analysis was done using Microsoft excel and Open Epi info software. Data was presented as Mean ± SD for quantitative data and as percentage for qualitative data. As a part of descriptive statistics, number of charts like Vertical Bar diagram and line chart were prepared. For continuous variables 't' test was used and for non-continuous variable chi square test was used, $p>0.05$ was considered as non-significant, $p<0.05$ was considered as statistically significant and $p<0.001$ was considered as highly significant.[14]

Results

Total 60 patients of age 14-65 years of either sex posted for elective procedures carried out under MAC from April 2018 to May 2019 were included in this study.

Table 1: Demographic data (n=60).

Variables	Mean ±SD	Other value
Age (years)	29.57 ± 11.86 years	Max age:66, Min age:14 years
Weight (kg)	53.68 ± 9.70 kg	Max:85 kg, Min:35 kg
Height (cm)	153.65 ± 4.53 cm	Max:170 cm, Min:148 cm

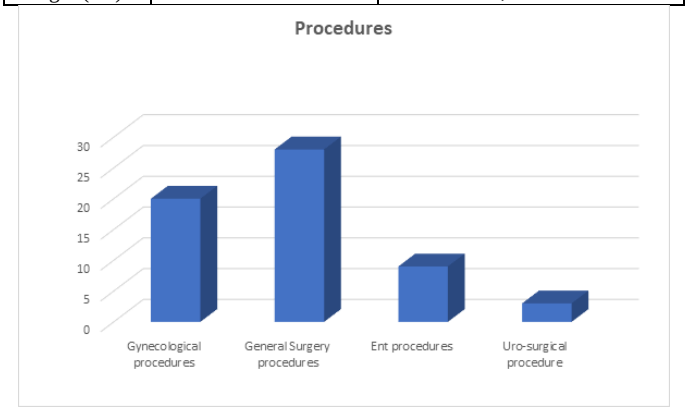

Figure 1: Types of procedures:

Out of 60 patients, maximum patients were from Gynaecology and General surgery department posted for short duration surgical procedures requiring sedation.

Table 2: Intervention

Interventions	Out of 60 Patients [n (%)]
Head tilt /jaw lift	24 (40%)
Oxygen administration by venti mask	19 (31.67%)
100% oxygen (Bains circuit)	08 (13.33%)
Oropharyngeal airway with 100% Oxygen	01 (1.66%)

Table 3: Mean RSS and Likert's scale

Variables	Median score	Mean score ±SD
Modified Ramsay Sedation score	3	2.96 ± 0.88
Likert patient's Score	6	6.42 ± 0.53
Likert surgeon's Score	6	6.92 ± 0.33

Discussion

Respiratory events like hypoventilation, apnoea, airway obstruction etc are frequently encountered during MAC sedation. An anaesthesiologist has to be vigilant in diagnosing such respiratory events to avoid sedation related adverse events. Capnography, a relatively new and useful technology for CO2 monitoring from exhaled air is capable of reliably monitoring respiratory pattern in spontaneously breathing patients.

The American Society of Anaesthesiologists (ASA),[15] Anaesthesia Patient Safety Foundation (APSF), Association of Anaesthetists of Great Britain and Ireland (AAGBI), and the Association of Anaesthesiologists in Holland have embraced and incorporated capnography into the standards of monitoring during anaesthesia to enhance patient safety. Currently, anaesthesiologists in many developing countries follow these recommendations (India, Government of Andhra Pradesh Order, AST/775/F25/dated September 2011. Capnography is mandatory for laparoscopic surgeries for reimbursement).

After approval from the institutional ethical committee, a prospective observational study was carried out in tertiary care hospital from 2018 to 2019. Total 60 participants were recruited for the study after written informed consent. Patient with age group of 14 to 65 years of either sex, BMI<35 kg/mtr2and ASA physical status 1 to 3 were included in present study.[16] Mean age in this study was 29.6 years and Mean weight was 53.68 kg. We had more than 96% patients ranging from BMI 18.5 to 29.9 kg/mtr2. Total 58.33% patients belonged to ASA physical status 2 and 26.67% patients belonged to ASA physical status 3.

In this study, maximum patients were from Gynaecology and General surgery department posted for short duration surgical procedures requiring sedation. All the standard monitors like ECG, NIBP and pulse oximeter were applied to the patient. They were visible to the sedation provider and surgeon as well as the nursing staff present in the operation theatre. The sedation provider was blinded to the capnography data throughout the procedure and monitored the patient clinically.[17,18,19]

When we compared intraoperative mean pulse, mean SBP, mean DBP readings at various time interval with the mean baseline reading, it was not significant ($p>0.05$) throughout the study. The result showed that it was comparable pre-procedure and intra-procedure without any major difference. So, we can assume that plane of anaesthesia was adequate in patients with the given sedation. D Oliveira G.S. et al (2014),[16] and Lightdale J.R. et al (2006),[21] observed stable hemodynamic throughout the study.

Table 4: Average dose of Inj. ketamine and Inj. propofol (n = 60)

Drugs	Out of 60 patients	Mean dose (mg)± SD	dose (mg/kg)
Ketamine	56 (93.33%)	53.50 ± 23.76	1 mg/kg
Propofol	58 (96.67%)	91.17 ± 49.58	1.70 mg/kg

This was an observational study and sedation provider was free to provide sedation with single drug or in combination with other. Sedation provider (who was involved in patient

care) administered drug to maintain Ramsay Sedation Scale equal to 3 score. Main anaesthetic agents used in the study were Inj. Propofol and Inj. Ketamine. Injection propofol was used in 96.67% patients as alone or with other adjuvants, with average dose 1.7 mg/kg which is permissible and safe range of propofol for sedation. Another main anaesthetic agent, injection ketamine was used in 93.33% patients, with average dose 1mg/kg which is also safe dose for sedation.

In present study, when we compared main anaesthetic agent with respiratory events, rate of respiratory events was 37.21 % with combination of injection ketamine and injection propofol in this study.

Burton J.H. et al (2005),[20] provided sedation with injection Propofol (68%), Inj. Ketamine (20%), Inj. Etomidate (7%), Inj. Midazolam (5%) and observed acute respiratory events in 18, 1, 1 & 0 patients respectively. Andolfatto G. et al (2012),[17] administered propofol and ketofol (1:1 mixture of 10 mg/ml of both the agents) as study medication and observed similar adverse respiratory event. Sivilotti M.L. et al (2008),[18] administered either 0.3 mg⁄ kg ketamine or 1.5 mcg ⁄ kg fentanyl followed by intermittent propofol. They observed brief, uncomplicated O_2 desaturation frequently in fentanyl group compared to ketamine group. Combined administration of ketamine and propofol was advantageous as each agent could theoretically counteract the other's undesirable effect.

On the contrary we found that, rate of respiratory depression was more than 50% with either ketamine or propofol alone and with combination of one of them with other agents (like inj. fentanyl), but there were very few cases of such incidences out of 60 cases to allow a meaningful analysis as required by our power of analysis.

When we compared various premedication/adjuvants used in this study, combination of Inj. pentazocine and Inj. promethazine and its association with respiratory events, it showed that rate of respiratory depression was 48% with this combination in our study. And the rate of respiratory depression was 42.86% with adjuvants Inj. dexmedetomidine and Inj. midazolam alone. On the contrary it showed that rate of respiratory events was more than 50% with other combinations, but there were very few cases to allow a meaningful analysis as required by our power of analysis.[22]

Table 5: Association between pre-procedure oxygen supplementation and respiratory events.

Pre procedure Supplemental O_2 (n=Patients)	Respiratory Events YES (n)	Respiratory Events NO (n)
19	1	18

O_2 was administrated as per the discretion of the sedation provider. In this study 19 (31.67%) patients received supplemental O_2 from the beginning of the study. Out of this 1 patient developed RD according to our pre-defined RD protocol.

In Miner J.R. et al (2002) study,[23] O_2 was started as per the discretion of the sedation provider. 64.4% of all patients were pre-treated with supplemental O_2. In Mehta J.H. et al (2017),[13] supplemental O_2 was provided to all patients in the procedural sedation and general anaesthesia groups throughout the procedure (p=0.86). In De Oliveira G.S. et al (2014),[16] and Lightdale J.R. et al (2006),[21] have started 4 L/min and 2 L/min supplemental O_2 to all the patients. Supplemental O_2 usually masks the conventional RE detection technique in terms of SpO_2 changes. Routine supplemental oxygen administration diminishes the value of pulse oximetry as a ventilatory monitor, since hypoxemia becomes a late sign of respiratory events. This can be correlated to our study in which respiratory events were probably masked by baseline supplemental O_2 and we have encountered only 1 case of RE in those patients.

Table 6: Respiratory Events

Events	Patients (n = 60)	Episode (n)
Respiratory depression (SpO2≤ 90 or RR≤8 or $EtCO_2$≥ 45) + Apnoea (Absence of $EtCO_2$ wave form for ≥ 15 sec)	27 (45%)	30

Out of 60 patients of the study, total 27 patients (45%) fulfilled either of the pre-defined RD criteria (SpO_2≤ 90 or RR≤8 or $EtCO_2$≥ 45) along with apnoea episodes in this study.

Table 7: Apnoea analysis

Detected by capnography	Episodes	Patients (n=27)
Apnoea	8	6 (22.22%)
Apnoea duration (seconds)	< 15 seconds → 4 episodes ≥ 15 seconds→ 4 episodes	

Out of these 27 patients, apnoea (absence of $EtCO_2$ waveform) episodes were detected only by the capnography in 6 patients. So, 10% patients out of 60 suffered from apnoea. These episodes were not diagnosed by the sedation provider by the conventional monitoring. Out of these 6 patients in whom apnoea was detected, 2 patients developed 2 episodes of apnoea. So, there were total 8 episodes of apnoea in this study. Out of these 8 apnoea episodes, 4 were of < 15 seconds duration and 4 episodes were of ≥ 15 seconds duration in whom the sedation provider was informed by the study investigator for the safety of patients.

Moreover, total (23.33%) patients developed hypoventilation ($EtCO_2$≤30 mm Hg with normal RR) and 3 episodes of hypopnea-hypoventilation ($EtCO_2$≥50 mm Hg and decreased RR) occurred in our study which were detected only by capnography. Hutchison R. et al (2008) [19] had defined respiratory depression by respiratory rate of 6 per minute or fewer, an apnoeic event lasting longer than twenty seconds, an end-tidal CO_2 level greater than 60 mmHg, or oxygen saturation less than 88%. Miner J.R. et al (2002),[23] had defined respiratory depression as an oxygen saturation of < 90% for at least 1 minute, an $EtCO_2$ of >50 mm Hg at any time, or airway obstruction with cessation of gas exchange at any time (noted by an absent $EtCO_2$ waveform).

SpO2, RR, $ETCo_2$ analysis: In present study nearly 96% episodes were there when SpO2 values was more than 91%. Whereas total 3.85 % episodes were there when SpO_2 decreased below 91% to be labelled as RD. In patients with RD for SpO_2, significant difference from baseline was noticed from 2 minutes onwards up to 10 minutes and at 16

min. As this was an observational study in which sedation provider was blinded to $EtCO_2$, RD was detected with the help of conventional techniques, out of which SpO2 appeared as sensitive parameter here for detection of RD. In Langhan M.L et al (2015),[15] the rate of O_2 desaturation significantly dropped over time in both capnography (n=77) and control (n=77) group (p=0.02). However, there was no statistically significant difference between the groups (p=0.80). In Miner J.R.et al (2002),[23] all patients had SpO2>96% prior to the procedure. 11 (74) patients were noted to have SpO2<90% at some point in the procedure. Out of 33 patients who developed RD, 11 had SpO2<90%. Out of these 11 patients, 5 patients were pre-treated with supplemental O_2.

When we compared mean RR at different time interval and compared with baseline mean RR, we found significant difference in RR in terms of either tachypnea or bradypnea in patients without RD. Significant difference was seen from 4th minute onwards, but could not reach at level to be labelled as RD. D Oliveira G.S. et al (2014),[16] observed that respiratory rates were lower in the saline group compared to ketamine group at all the time interval from 5 to 45 minutes.

In present study less than 10% episodes were recorded with $EtCO_2$ values >45 mm Hg during study and in <32.26% episodes, $EtCO_2$ value was ≤30 mm Hg. In patients with RD for mean $EtCO_2$, significant difference from baseline was noticed at 2 minutes, 8 min and at 14 minutes. At rest of the time intervals, $EtCO_2$ values were comparable to the baseline values. In non-RD patients, significant difference was noted in $EtCO_2$ value from the baseline at only 12 minutes of duration but was not labelled as RD because value could not meet RD criteria.

Mehta J.H. et al (2017),[13] had documented that mean $EtCO_2$ value was higher in general anaesthesia (37.2±4.3 mmHg) group than procedural sedation (23.3±4.8 mmHg) and awake volunteers (31.4±5.2 mmHg) groups (p<0.0001). Van loon K. et al (2014),[22] observed that capnographic changes preceded in 63% of the desaturation episodes. In 25.6% cases capnography showed absent alveolar plateau and in 5.8% cases low $EtCO_2$ values. In contrast to these studies, Hutchison R. et al (2008),[19] observed that an end-tidal CO_2 level of greater than 60 mm Hg and oxygen saturation of less than 88% did not contribute to the respiratory depression outcomes, suggesting that they may be less sensitive indicators of changes in respiratory function.

Table 8: Mean RR, SpO_2 and $EtCO_2$ (Baseline vs. Intra Procedure).

Pre-Procedure	MEAN ± SD	Intra-procedure	MEAN ± SD	P-Value
Mean RR (rate/min)	18±2	Mean RR	19 ±4	0.08
Mean SpO_2 (%)	98±0.87	Mean SpO_2	97±2	0.005*
Mean $EtCO_2$ (mmhg)	35.7 ± 4.53	Mean $EtCO_2$	37±6	0.183

When intraoperative mean SpO_2 was compared to baseline mean SpO_2 readings, it was statistically significant (p<0.05) though clinically insignificant. Intraprocedural mean RR was comparable with baseline mean RR (p=0.08). When we compared intraprocedural mean $EtCO_2$ value with mean baseline $EtCO_2$ value, we found p value of 0.183. So, the difference was not significant for $EtCO_2$. So, intraoperatively mean RR and mean $EtCO_2$ were comparable to mean baseline values. *(p<0.05 is significant).

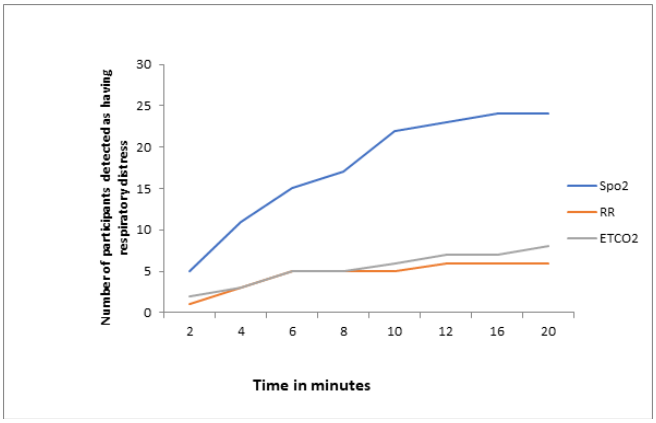

Figure 2: Association of SpO2, RR and EtCO2 in Respiratory depression patients.

This is the graphical presentation of correlation of main three parameters SpO_2, RR and $EtCO_2$ studied during this observational study in short duration procedures conducted under sedation. Total 30 episodes (27 patients) of RD were documented in this study by either of the RD criteria (SpO_2 ≤ 90% or RR ≤ 8 breaths/min. or $EtCO_2$ ≥ 45 mm Hg). When we correlated all the 3 parameters, SpO2 detected RD in 22 patients within 20 minutes of starting procedures in different patients. Whereas RR and $EtCO_2$ detected RD in 5 and 7 patients respectively either alone or with other parameters. Out of these 27 patients of RD, in 3 patients capnography detected RD before pulse oximetry as per our RD criteria. In nutshell, SpO2 seemed to be the sensitive parameter in this study for the detection of RD as compared to other methods. Van loon K. et al (2014),[22] observed that capnographic changes preceded the period of hypoxemia (SpO2<91%) in 63% of the desaturation episodes. Capnography showed an absent alveolar plateau in 25.6% patients and apnoea in 18.6% of patients before hypoxemia occurred. Lightdale J.R. et al (2006),[21] documented poor ventilation in 3% of all procedures and no apnoea. Whereas, Capnography indicated alveolar hypoventilation during 56% of the procedures and apnoea during 24% of the procedure. Burton J.H. et al (2005),[20] documented 20 acute respiratory events in the 60 PSA (procedural sedation and analgesia) patients (33%). Out of these seventeen patients (85%) demonstrated $EtCO_2$ findings indicative of hypoventilation or apnoea. These findings were documented before changes in SpO2 or clinically observed hypoventilation in 14 patients (70%) with acute respiratory events. Miner J.R. et al (2002),[23] observed 33 out of 74 patients developed RD. Seven patients met two criteria and one patient met all the three criteria. Pulse oximetry detected 11 of the 33 patients with RD. Using criteria of $EtCO_2$ >50 mm Hg, an absolute change of $EtCO_2$ >10 mm Hg and an absent $EtCO_2$ waveform may detect subclinical RD not detected by pulse oximetry alone.

If gas inflow is constant, Capnography provides qualitative and quantitative measure of ventilation, but it provides only an approximation of changes in tidal volume, as noted by the wave form. Increasing oxygen flow rates decreased the amplitude of measured CO_2, probably via dilution, making the quantitative value as an assessment of ventilation less reliable. All episodes of apnoea, however, were still detected accurately regardless of the flow rate in our study.[8,9]

As in shown in table no 2, out of 60 patients, 36 patients required intervention. 24 (40%) patients required head tilt/jaw thrust at any time during the sedation. In 8 patients (13.33%), due to hypoxemia and shallow breathing 100% O_2 was given for few minutes at some point of time. Total 19 (31.67%) patients were administered O_2 via venti-mask with O_2 flow rate ranging from 4 lit/min to 8 lit /min. All the interventions were timely done without any delay.

Table 9: Incidence of Interventions in patients with/without Respiratory events.

Out of 60 patients	Interventions (n (%))		P-value
	Yes (n=36)	No (n=24)	
Patients with RE (n=27)	25 (41.67)	02 (03.33)	<0.0001
Patients without RE (n=33)	11 (18.33)	22 (36.67)	

Out of those 27 patients with respiratory events (RE) total 25 patients required intervention. While in rest 33 patients without RE, 11 patients required intervention. When we compared interventions in patients with RE and without RE, p value was <0.001. This suggested that difference was statistically highly significant. Hence, RE patients required more interventions compared to non-RE patients. In Langhan M.L. et al (2015),[15] there were significantly fewer interventions in the intervention group than in the control group. The intervention group was more likely to receive timely interventions occurring simultaneously with hypoventilation. Only 6 patients required supplemental O_2 as intervention. Van loon K. et al (2014),[22] observed incidence of airway interventions performed was significantly higher in the capnography group. 102 (49.5%) patients in the capnography group and 67 (32.1%) patients in the standard care group underwent a chin-lift or jaw-thrust at least once during the procedure (p< 0.001). Supplemental oxygen was administered in 26 (12.6%) patients in the capnography group and 17 (8.1%) patients in the standard care group (p=0.134). Burton J.H. et al (2006),[20] observed 20 patients developed respiratory events. Out of which, stimulation of patients by physical or verbal means required in all 20 patients, increased O_2 required in 14 patients, 9 patients required repositioning and 4 patients required use of bag-valve-mask for ventilation.

Table 10: Association between duration of procedure and respiratory events.

Duration (minutes)	Patients with RE (n=27)	% Out of RE Patients
1 to ≤ 30	24	88.89
31 to ≤ 60	2	07.69
61 to ≤ 90	1	03.85

In present study respiratory events was seen in 27 patients out of which 24 (88.89%) patients had undergone different procedures of 30 minutes duration. Only one procedure lasted more than 60 minutes in which RE was encountered within 20 minutes of starting the procedure. Mean duration of surgery was 25.92 ± 14.77 min. while mean duration of sedation was 26.43 ± 14.52 min. When we compared the duration of surgery and sedation, it showed p value 0.8491 (>0.05). So, it suggested that patients were not over sedated post procedure in this study.

In this study, the adverse events observed were transient and were of minor consequence. So, all the 60 patients completed the surgical procedure successfully. In contrast to our study, Van loon K. et al (2014),[22] documented three patients from the capnography group had their sedation prematurely terminated, because in 1 patient, the gynaecology procedure could not be performed due to technical difficulties and in 2 patients, respiratory function was seriously compromised during sedation. In, De Oliveira G.S. et al (2015),[16] one patient in the placebo group was unable to tolerate the procedure under sedation, which was converted to general anaesthesia.

Conclusion

Though, the value of capnography in monitoring ventilation in patient undergoing procedure under sedation is well appreciated, we could identify only few cases of respiratory depression by capnography as compared to pulse oximetry in our study. Also, the anaesthesiologists providing sedation were vigilant and were able to provide timely intervention in our study. Thus, capnography cannot replace clinical observation methods and pulse oximetry in identifying respiratory events. But its value cannot be neglected also, as capnography serves as a warning monitoring tool by instantly drawing anaesthesiologist's attention.

Strengths of the study: All the data and observation were done by single investigator so there was no possibility of interobserver variation in data, there was no sampling bias in the study, sedation provider was blinded to the capnographic data.

Limitations of the study: We targeted our sedation protocol to a Ramsay Sedation Scale instead of using a depth of anaesthesia monitor such as the bispectral (BIS) index monitor. We only studied healthy patients and the number evaluated is too small to assess the risk of serious side-effects. This study included the 15 seconds alarm limit for apnoea. However, keeping the longer apnoea time might result in more significant arterial oxygen desaturation and hypercapnia, placing the patient at an unacceptable risk.

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