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Original Article

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ABSTRACT

Objectives: To investigate the end tidal carbon dioxide pressure values in order to determine carbon dioxide accumulation under surgical drapes and it's hemodynamic effects based on anesthetic and surgical records in eye surgeries under local anesthesia.

Design: Retrospective study

Setting: Department of Anesthesiology and Reanimation, Düzce Medical Faculty, Düzce, Turkey

Subject: The data were collected from anesthetic records of patients (n=42) who were followed with noninvasive capnography in the operating room at Düzce University Hospital during the period of January 2016 to December 2016. Systolic, diastolic and mean arterial pressure, operation time, heart rate, ST segment analysis, $ETCO_2$ pressure, pulse oximetry values were recorded. Time periods were determined as: after the anesthesia and before drape closure (baseline level), at 10^{th}, 15^{th}, 20^{th}, 45^{th} of the surgery and 5 minutes after drape removal.

Intervention: Non-interventional

Main outcome measure: Carbon dioxide accumulation under drapes and it's hemodynamic effects in eye surgeries under local anesthesia.

Results: The comparisons were made with basal status and time periods statistically. There wasn't found any differences between mean arterial pressures, heart rates, arrhythmias and pulse oximetry values of patients between time periods. We observed significant differences for $ETCO_2$ levels between basal and the other time periods, except remove the drapes (*P*=.001).

Conclusion: Routine monitorisation of $ETCO_2$ with noninvasive capnography provides early detection of CO_2 accumulation and CO_2 rich air breathing during ophthalmic surgery.

KEY WORDS: ambient air quality monitoring, carbondioxide accumulation, end-tidal carbondioxide, eye surgery, surgery drapes

INTRODUCTION

The patients who undergo ophthalmic operations with spontaneous breathing may be exposed to exhaled carbon dioxide accumulation because of covering with ophthalmic drapes. This elevated carbondioxide levels may aggravate the haemodynamic and cardiac changes of the patients. These changes also cause significant changes in cerebral blood volume and intracranial pressure [1].

Cerebral blood flow (CBF) is controlled by arterial blood pressure, arterial CO_2, arterial O_2, and brain activity and is largely constant in the awake state. Although small changes in arterial CO_2 are particularly potent to change CBF (1 mmHg variation in arterial CO_2 changes CBF by 3-4%), the coupling mechanism is incompletely understood [2-3]. Elevated carbon dioxide (CO_2) blood levels have a depressant effect on the central nervous system and can lead to coma in adults. Less is known about the effect of CO_2 on the neurological function of infants [4].

The aim of this retrospective study is to determine the accumulation of carbon dioxide under cover and to investigate its side effects based on anesthetic records in eye surgeries under local anesthesia.

SUBJECTS AND METHODS

After approval from the Düzce Faculty of Medicine Noninvasive Researches Ethics Committee (02.01.2017), the data were collected patients (586 patients totally: 79 had sterile surgical cotton fabric drapes, 501 had sterile plastic drape, 6 had no records) anesthetic forms who were followed with capnograph (Capnostream 20 p, Oridion, Israel) + sterile 3M plastic drape (n=42 patients) by the anesthesiology department for eye surgery in the operating room at Düzce University Faculty of Medicine Hospital during the period of 01 January 2016 to 31 December 2016. We excluded patients except those who used capnostream capnograph + 3M plastic during surgery. It was observed that 42 patient records met the retrospective study criteria. Demographic and clinical datas were abstracted from anesthetic and clinical records.

When the cases were evaluated in terms of carbon dioxide accumulation, it was observed that most of the patients were not followed up with carbon dioxide. It was also found that there were used two types of sterile drape (sterile cotton fabric surgical drape and 3M sterile drape) during these operations. It was determined that the carbon dioxide measurements were done by attached at the end of the capnograph sample line near the mouth of the patients or the carbon dioxide levels of the patients (42 patients) were measured using the capnostream capnography device. For this reason, only the capnostream capnographic device and the data of the patients using plastic 3M sterile drape were evaluated in order to obtain the correct data. Capnostream capnograph records were taken from memory USB device.

Age, weight, height of the patients, operation types, operation duration times, local anesthetic performing types, noninvasive systolic, diastolic and mean arterial pressure, heart rates, ST segment analysis (Datex Ohmeda monitor, GE HealthCare, Finland). Systolic, diastolic and mean arterial pressure measurements, end tidal carbon dioxide levels, pulse oximeter values were extracted from anesthetic forms retrospectively. Arrhythmia recordings were evaluated as (yes / no) over time periods.

Surgical field was covered with reusable cotton fabric drape or disposable surgical adhesive plastic drape (SteriDrape, 3M). We included the patients records who were covered with the same kind of drapes (SteriDrape, 3M). We exclude records with another type of drape usage or without drape usage type to provide the homogenization and clarity of the results.

Data were collected from the anesthetic forms which time periods were determined as the baseline, before closing drape, at 10^{th}, 15^{th}, 20^{th}, 45^{th} minutes after covering and 5 minutes after drape removal. Records with pulmonary disease, diabetes mellitus and sedative usage, alcohol usage were excluded from the study. The comparisons were made with patients basal status and time periods statistically.

Statistical analysis

Descriptive statistics (mean, standard deviation, median, minimum, maximum, percent) of all variables included in the study were calculated. The normality assumption for quantitative variables was examined by the Shapiro Wilk test. Variables that did not provide a normality assumption were subjected to Box-Cox transformation. Repeated Measures ANOVA (post hoc Fisher's LSD test) was used to compare time-dependent quantitative variables. The Cochran Q test was used to compare categorical variables

measured at different periods. SPSS 22 program was used for statistical evaluations and *P*<.05 was considered statistically significant.

RESULTS

Between January and December 2016, the cases who had undergone local eye operation were examined from the Düzce University Hospital records. A total of 586 patients who had undergone local eye surgery at the specified time interval were identified. Of these patients, 79 had sterile surgical cotton fabric drapes, 501 had sterile plastic drape and six had no records.

It was determined that the tip of the capnograph sample line of end-tidal CO_2 monitoring in 107 was measured by the patient's mouth (65 patients) or using a noninvasive capnography device (42 patients).

Researchers detected this 42 records which provide search criterias as follows: Cataract surgery was performed via phacoemulsification in 36 of the 42 records (86%), and extracapsular cataract extraction (14%) was applied to the remaining 6 records. Thirty-nine (93%) of the records were given topical and three (7%) were subjected to retrobulbar anesthesia. The mean duration of operation was 30.45±14.48 minutes (range: 10-60 minutes). It was observed that operation duration time were under 20 minute in ten patients. Only one patient had under 10 minute duration time. Approximately ¾ of the 42 patients duration times were equal or longer than 20 minute. Also 25 of 42 patients were female and 17 of them were male.

We detected that 2 l / min oxygen delivery was performed all 42 patients from digital consumption data records of our hospital.

Systolic arterial pressure (SAP) values at different periods were found to change significantly with time (*P*=.006). SAP values were found to decrease from basal levels on SAP 10^{th} minute(*P*=.016), SAP 15^{th} minute (*P*=.025), SAP 20^{th} minute (*P*=.031), SAP 30^{th} minute (*P*=.004) and SAP after drapes were removed (*P*<.001). Additionally, SAP values were found to decrease from after the drapes covered the operation area levels on SAP 10^{th} minute (*P*=.012), SAP 15^{th} minute (*P*=.018), SAP 20^{th} minute (*P*=.023), SAP 30^{th} minute (*P*=.003) and SAP values after drapes were removed (*P*<.001)

It was determined that the mean arterial pressure values measured at different periods did not change significantly depending on the time (*P*=.129, Figure1). It was found that the end-tidal carbondioxide ($EtCO_2$) values measured at different periods changed significantly with time (*P*=.001). $EtCO_2$ values were found to increased from basal levels on $EtCO_2$ values after drapes were covered, $EtCO_2$ values 5^{th} minute (*P*<.001), $EtCO_2$ values 10^{th} minute (*P*<.001), $EtCO_2$ 15^{th} minute (*P*<.001), $EtCO_2$ values 20^{th} minute (*P*<.001), $EtCO_2$ values 30^{th} minute (*P*<.001) and $EtCO_2$ values after drapes were removed (*P*<.001, Table 2). Additionally, SAP values were found to decreased from after the drapes covered the operation area levels on SAP 10^{th} minute (*P*=.012), SAP 15^{th} minute (*P*=.018), SAP 20^{th} minute(*P*=.023), SAP 30^{th} minute (*P*=.003) and SAP after drapes were removed (*P*<.001, Figure 1).

The SpO_2 values measured at different periods were found not to change significantly with time (*P*=.863). It has been determined that the heart rate values measured at different periods did not change significantly with time (*P*=.076).

It has been determined that ST values measured at different periods change significantly with time (*P*=.021). ST segment analysis was found to increased from basal levels on 10th minute (*P*=.019),15th minute (*P*=.013), 20th minute (*P*<.001), 30th minute (*P*<.001) and after drapes were covered (*P*<.001). In additionally ST segment analysis was found increased when compared with after drapes covered levels on 15th minute (*P*=.036), 20th minute (*P*=.003), 30th minute (*P*=.002). ST values were shown to also decreased nearly basal levels after drapes were removed. It was observed that the arrhythmia state examined at different periods was not significantly different (*P*=.429). It has been determined that the respiratory rate values measured at different periods changed significantly depending on the time (*P*<.001).

It was observed that the arrhythmia status was not differentiated significantly at different periods (*P*=.429, Table 1).

DISCUSSION

The vast majority of cataract operations are performed between 70-90 years old [5]. Fifty percent of cataract operations are performed with local anesthesia while spontaneously breathing [6] .

In this age group, the incidence of one or more comorbidities such as diabetes, hypertension, coronary artery disease, heart failure, chronic renal failure is high [5]. Intraoperative monitoring methods for the early diagnosis and prevention of hemodynamic and cardiovascular complications that may occur during the operation, while the medical records of these high-risk patients should be renewed before operation too. Recommendations are take an attention that all patients undergoing major eye surgery under local anesthesia should have careful monitoring including pulse oximetry, ECG, noninvasive blood pressure and end-tidal carbon dioxide measurement [7].

Several studies have shown that hypercapnia leads to coronary vasodilatation and has cardiac depresant effects [8]. In addition it was demonstrated that administration of a gas mixture containing 20 % carbondioxide caused marked depression of myocardial contractility in cats [8-12]. Abnormal ST-T segment changes identical those of ischemia. The patient which coronary blood flow does not increase adequately when increase in cardiac work demand under risk of impared contractility of the heart, hypotension, arrhytmias and death [13].

Conventional facial masks make the surgical procedure difficult because they are so close to the operating area that they are used to provide oxygenation in eye surgery [14].

Various methods have been tried to be developed to detect carbon dioxide accumulation under drapes [14-19]. In studies nasal sampling line connected to Datex Capnomac Ultima monitör but end-tidal carbon dioxide accumulation was not detected [14]. In another study, end-tidal carbon dioxide was measured with the help of an anesthesia monitor device which has got (Cardiocap Datex, Helsinki, Finland) a special apparatus placed between the drapes and the faces of the patients. In this study, transcutaneous partial carbon dioxide ($PtcCO_2$) was also measured.

Also in this study, it is stated that this increase in the endodal carbon dioxide values can not be measured by routine monitoring methods and that the applied oxygen supplement does not prevent carbon dioxide accumulation [15].

Microstream technology used on Capnostream 20p capnograph for continuous view of ventilation adequacy on intubated and non-intubated patients from neonate to adult.

These devices use for eye surgery in our clinic and all of the end-tidal carbon dioxide recordings in our surveys have been observed to be obtained by means of a nasal cannula extending to the mouth and measuring the pulse oximetry and end tidal carbon dioxide measurement allowing both oxygen delivery. The four parameters that measures of this device are: $EtCO_2$, SpO_2, respiratory rate (RR) and Pulse Rate (PR) are integrated to give one number called Integrated Pulmonary Index (IPI) [19]. It has been observed that the records of the Integrated Pulmonary Index are not available in our records.

In our records there was no statistically significant change in noninvasive, mean, diastolic arterial blood pressure, and heart rate as a function of time compared to baseline levels of the patients, but noninvasive systolic arterial pressure increased statistically significantly during operation compared to baseline values.

A meaningfully and statistically significant increase that observed in the end-tidal carbon dioxide levels indicates the accumulation of carbon dioxide under the cover. But no new arrhythmia patterns noted was observed in any of the patients in our records. When the ST segment changes were examined in our records, it was found that there was an increase in the ST segment in the positive direction, that is, statistically and clinically significant ST elevations were observed.

In this sense, we think that the effects on the cardiovascular system can be evaluated more clearly by examining the serial electrocardiogram records to be taken in future prospective studies together with the increase of the underlying end-tidal carbon dioxide levels.

The Joint Working Party on Anesthesia in Ophthalmic Surgery by the Royal College of Ophthalmologists report at february 2012 recommended monitoring methods include: communication, clinical observation, pulse oximetry (SpO2), electrocardiogram (ECG), non-invasive blood pressure (NIBP). But end-tidal carbon dioxide measurements not included this schemas yet. Our aim in this study is to investigate the accumulation of carbon dioxide under drapes in eye surgery under local anesthesia and to raise awareness of the potential hazards of this accumulation. At the same time, we think that end-tidal carbon dioxide monitoring must be included in the necessary and basic monitoring techniques in these kind of operations.

CONCLUSION

End-tidal carbon dioxide levels should be monitored in patients in whom sedation is performed, the airway is not secured and the anesthesiologist is difficult to reach, in the patient group who can accumulate carbon dioxide under the cover and cannot tolerate hypercarbia.

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All author’s contributed equally in the manuscript.

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Table 1: Distribution of arrhythmia status at different periods

Distribution of arrhythmia		n	%
Basal	Yes	4	9.5
	No	38	90.5
	Total	42	100.0
Before drape closure	Yes	4	9.5
	No	38	90.5
	Total	42	100.0
5th minute	Yes	4	9.5
	No	38	90.5
	Total	42	100.0
10th minute	Yes	4	9.5
	No	38	90.5
	Total	42	100.0
15th minute	Yes	4	11.1
	No	32	88.9
	Total	36	100.0
20th minute	Yes	2	8.0
	No	23	92.0
	Total	25	100.0
30th minute	Yes	0	0.0
	No	17	100.0
	Total	17	100.0
45th minute	Yes	0	0.0
	No	6	100.0
	Total	6	100.0
After drapes removed	Yes	5	11.9
	No	37	88.1
	Total	42	100.0

Table 2: End tidal carbondioxide records in time periods

	n	Mean(mmHg)	Standart Deviation(mmHg)	Minimum(mmHg)	Maximum(mmHg)
Basal	42	32,38	5,85	17	49
Before drape closure	42	35,17	4,66	28	47
5th minute	42	36,21	4,16	28	46
10th minute	42	36,48	4,33	29	47
15th minute	35	35,57	4,70	26	47
20th minute	25	34,92	4,13	26	43
30th minute	17	35,18	4,11	28	46
45th minute	6	35,83	3,76	29	39
After drape removal	42	32,36	5,62	21	44

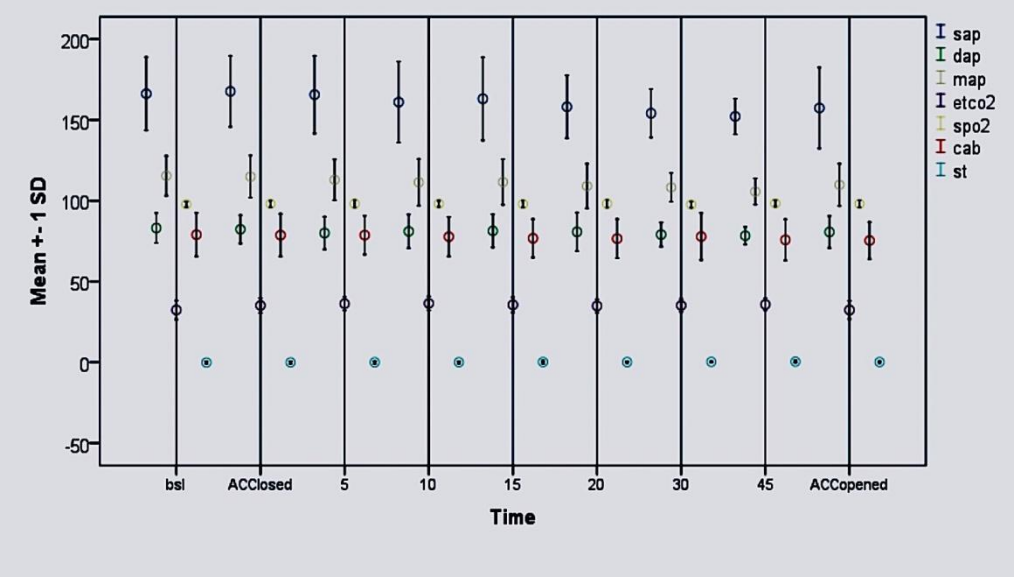

Figure1: Non-invasive Systolic (sap), diastolic (dap), mean (map) arterial pressure, end-tidal carbondioxide (etco2), pulse oximeter (spo2), ST segment (st) and heart rate (cap) level changes of the patients. Bsl: basal levels, ACClosed: after drapes were covered, 5, 10, 15, 20, 30, 45 min after drapes were covered, ACCopened: 2 minutes after drape removed. There wasn't found any differences between mean arterial pressures, heart rates, arrhythmias and pulse oxymeter values of patients in time periods. We observed significant differences for end-tidal carbon dioxide levels between basal and the other time periods, except remove the drapes. (p=0.001)