Gastric Insufflation and Ventilatory Mode during Induction of Anesthesia: A Prospective Randomized Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Mechanical ventilation is a fundamental tool in daily anesthetic practice.
Several ventilation modes are used for the ventilation of patients during the induction of general anesthesia; the controlled volume mode is most commonly used by anesthesiologists.
Ventilation often causes gastric insufflation, which may be responsible for gastric fluid inhalation, with serious consequences.
The aim of our study was to compare the incidence of gastric insufflation according to the ventilatory mode used during anesthesia induction.
Methods: This was a randomized prospective study carried out in the central operating complex of the Mohamed V Military Teaching Hospital in Rabat for a period of 06 months between January and June 2021.
The patients included in our study were candidates for laparoscopic cholecystectomy.
Gastric insufflation was assessed using epigastric auscultation. Finally, it is evaluated using the camera.
Results: During the study period, 120 patients were enrolled and divided into three groups of 40 patients according to the ventilation mode used: Group VM (Manual Mode), Group VV (Controlled Volume Mode) and Group VP (controlled pressure Mode).

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There were no statistically significant differences between the three groups in terms of hemodynamic and respiratory parameters.
Gastric insufflation rate was lower in the VP group (14%).
The pressure-controlled ventilation mode causes less gastric insufflation without additional hemodynamic or respiratory cost and gives the surgeon greater comfort without the need for a stomach probe.

1. INTRODUCTION

Mask ventilation is commonly used in anesthesia and emergency medicine to maintain adequate alveolar ventilation and arterial oxygenation pending intubation.

Its main disadvantages are hypoventilation (hypercapnia, hypoxia) and gastric insufflation with a risk of aspiration of the gastric fluid.

During mask ventilation and when the airway pressure exceeds that of the lower esophageal sphincter, the volume administered to the patient will not be directed exclusively to the lungs but partly to the stomach [1,2].

Although the pressure of the lower esophageal sphincter is estimated at 16 cmH2O in the awake patient, it gradually decreases during the induction of general anesthesia. Thus, insufflated air passes easily into the digestive tract causing gastric distension [3,4].

The aim of our study is to compare the incidence of gastric insufflation according to the three facemask ventilation modes used during the induction of general anesthesia (manual mode, controlled volume mode and controlled pressure mode) in taking laparoscopic cholecystectomy as a surgical model.

2. METHODS

This is a single-center randomized prospective study carried out in the central operating complex of the Mohammed V military teaching hospital in Rabat over a period of 06 months between January and June 2021.

The study had the approval of the Hospital Research and ethics Committee.

We included in our study 120 ASA I or II patients who were candidates for planned laparoscopic cholecystectomy under general anesthesia with tracheal intubation.

We excluded from our study pregnant women, patients with a BMI>35 and patients with a history of difficult intubation or anticipated difficult intubation.

The anesthesia machine used is Dräger (Primus, Lübeck, Germany).

In the operating room, standard monitoring made of a cardioscope, a BP cuff and a pulse oximeter is applied.

In all patients, after taking a peripheral venous route, premedication with Midazolam 0.03mg/kg is administered with pre-oxygenation mask at a flow rate of 10l/min for 3 minutes.

Induction of general anesthesia was performed in all patients by: Fentanyl 3 µg/kg, Propofol 3 mg/kg and Rocuronium 0.6 mg/kg.

After the loss of the verbal response, the chronometer is started, a Guedel cannula is put in place, a suitable facemask is applied to the patient and ventilation is started according to the ventilation mode chosen.

We divided the patients into three groups of 40 according to the ventilation mode chosen, GROUP VM (manual ventilation), GROUP VV (volume-controlled ventilation) and GROUP VP (pressure-controlled ventilation).

In Group VM patients, the APL valve is set at 15mmHg, the gas flow at 10 l/min, and the FiO2 at 1.

In patients in the VV group, the ventilatory parameters were set as follows: Tidal volume at 7 cc/kg of theoretical ideal weight, respiratory rate at 12 cycles per minute, PEEP at 5 mmHg, I/E ratio at 1 /1.2 and 1 FiO2.

In patients in the VP group, the inspiratory pressure is set at 15 mmHg, the frequency at 12 cycles per minute, a PEEP at 5 mmHg, an I/E ratio at 1/1.2 and the FiO2 at 1.

Ventilation was ensured according to the ventilatory mode chosen by the same practitioner for 2 min in all patients, while another operator performs epigastric auscultation for the detection of gastric insufflation and the transcription of the results on the form.

Respiratory and hemodynamic parameters were recorded every 30 seconds until intubation and balloon inflation.

The respiratory parameters recorded are SpO2, et CO_2, inspired volume, expired volume, leak volume and airway pressure.

The volume of the stomach is evaluated by the surgeon after introduction of the camera and qualified as low, medium or large, justifying the use of a stomach tube.

Results are presented as meanSD and ranges. Statistical analysis was done using the IBM SPSS 20.0 software.Statistical analysis was performed using one-way Analysis Of Variance 'ANOVA' tests. Post Hoc-Dunnett T3, multiple comparisons were used with 95% confidence intervals to compare between each pair of the three modes. Data were considered statistically significant when $P<0.05$.

3. RESULTS

During the period of the study extended over 06 months between January and June 2021, we collected 120 patients divided into three groups according to the ventilation mode chosen.

4 patients were excluded from the study due to the unexpected occurrence of desaturation below 90% due to ineffective ventilation or unpredictable difficult intubation requiring the use of several maneuvers with prolongation of ventilation.

3.1 Patient Demographics

The average age of the patients was 49 years (20-80 years) with a sexratio of ¼. The average weight of 75 Kg (45-105). The average BMI was 26.9 Kg/m2. 84 patients were classified as ASA 1 and 32 patients as ASA2.

The following Table 1 summarizes patient demographics:

Regarding the demographic criteria, there was no statistically significant difference between the three groups of patients.

3.2 Criteria for Difficult Ventilation and Intubation

The breakdown of difficult mask ventilation and difficult intubation criteria is summarized in Table 2.

There is no statistically significant difference in the ventilation and difficult intubation criteria between the three groups of patients.

Table 1. Patient demographics

Data	Values			
	Group VM (n=39)	**Group VV (n=39)**	**Group VP (n=38)**	**p values**
Age (years) [#]	48.5±14.5	51±14.5	48±12	0.653
Sex[§]				0.954
Men	8(20.5%)	7(18%)	7(18.4%)	
Women	31(79.5%)	32(82%)	31(81.6%)	
ASA[§]				0.240
I	29(74.3%)	27(69.2%)	28(73.7%)	
II	10(25.7%)	12(30.8%)	10(26.3%)	
Weight (kg) [#]	72.5±10.8	76.3±12	76.6±10.7	0.199
Height (cm) [#]	166.3±5.14	167±4.4	167.5±4.9	0.537
BMI (kg/m2) [#]	26.22±3.8	27.2±4.14	27.3±3.8	0.377

 # Expressed as mean±deviation
§ Expressed in numbers (percentage)
BMI: Body Mass Index
ASA: American Society of Anesthesiologists

Table 2. Difficult ventilation and intubation criteria

Data	Values			
	Group VM (n=39)	**Group VV (n=39)**	**Group VP (n=38)**	**p values**
Beard[§]	2(5%)	0(0%)	0(0%)	0.134
Toothless[§]	8(20%)	7(18%)	4(10.5%)	0.471
Snoring[§]	7(18%)	14(36%)	12(31.6%)	0.187
Sunken cheeks[§]	3(7.7%)	5(13%)	5(13%)	0.694
Large Tongue[§]	1(2.5%)	1(2.5%)	1(2.6%)	1
Rétrognathism[§]	2(5%)	2(5%)	0(0%)	0.240
Mallampati Score[§]				0.898
I	19(48.7%)	19(48.7%)	20(52.6%)	
II	20(51.3%)	20(51.3%)	18(47.4%)	
HMD < 6.5 cm[§]	2(5%)	3(7.7%)	1(2.6%)	0.560
MO < 3 FB[§]	1(2.5%)	3(7.7%)	3(7.9%)	0.535
Limited Neck mobility [§]	0(0%)	2(5%)	3(7.9%)	0.223

§ Expressed in number (percentage)
HMD: Hyoid-Mentum Distance
MO: Mouth Opening
FB: Fingerbreadths

Table 3. Hemodynamic and respiratory parameters during ventilation

Data	Values			
	Group VM (n=39)	**Group VV (n=39)**	**Group VP (n=38)**	**p values**
MAP[#]	85±14	92±29	89±14	0.241
SpO2[#]	99.9±0.1	99.5±0.2	99.8±0.2	0.332
EtCO2[#]	21±10	22±8	24±7	0.258
Gastric insufflation [§]	21(54%)	16(41%)	6(14%)	0.001
Stomach volume[§]				0.003
Low	13(33.3%)	12(30.7%)	27(71%)	
Medium	12(30.7%)	11(28.3%)	6(15.8%)	
Large	14(36%)	16(41%)	5(13.2%)	
Stomach probe[§]	26(68.4%)	27(69%)	11(29%)	0.001

 # Expressed as mean±deviation
§ Expressed in numbers (percentage)
For hemodynamic and respiratory parameters, we did not record a statistically significant difference between the three groups

3.3 Hemodynamic and Respiratory Parameters during Ventilation

Hemodynamic and respiratory parameters were recorded throughout the ventilation and are summarized in Table 3.

For gastric insufflation there is a statistically significant difference between the three groups in favor of the VP group providing the lowest rate of gastric insufflation and consequently a small stomach volume and less use of a stomach tube.

No case of aspiration was recorded during induction in the patients of the three groups.

4. DISCUSSION

Aspiration is the leading cause of death related to general anesthesia [5]. This inhalation is favored by several factors, including the gastric volume, which can be greatly modified by the passage of air in the stomach during the patient's ventilation.

The aim of our study is to compare the incidence of gastric insufflation according to the ventilatory mode used during the induction of general anesthesia.

Several studies have focused on studying the ventilation modes used during the induction of

general anesthesia and the incidence of gastric insufflation.

In a previous study [6], Authors compared the real-time occurrence of gastric insufflation secondary to pressure-controlled facemask ventilation using gastric ultrasound and epigastric auscultation in non-curarized patients. They collected 67 patients divided into 4 groups according to the level of pressure chosen: 10, 15.20 and 25 cm H2O.

Another one [7] compared the three modes of ventilation with a facemask during the induction of general anesthesia. This study included 90 patients divided into 3 groups of 30 according to the ventilation mode chosen initially.

In our study, concerning the demographic criteria and the pathological history, there were no statistically significant differences between the three groups of patients.

The distribution of the criteria of difficult mask ventilation and difficult intubation was practically homogeneous between the three study groups and there was no statistically significant difference.

Also in the aforementioned studies, there was no significant difference in patient characteristics.

In our study, we homogenized the anesthetic procedure by following a single protocol in all patients.

Also, all patients were scheduled for the same type of surgery (laparoscopic cholecystectomy), which allowed us to directly visualize the volume of the stomach by the camera in addition to the auscultatory method used in the other two studies.

The haemodynamic parameters were similar in all the patients and the MAP curves of the patients of the three groups remained contiguous.

In the study by Mustapha M. Seed, et al. The authors recorded MAP and heart rate in all patients and found no significant difference.

In the study by Bouvet et al. the hemodynamic parameters were not recorded and the authors were only interested in the respiratory parameters and the detection of gastric insufflation simultaneously by the two methods: auscultation and ultrasound.

The respiratory parameters were also close in the three groups of patients and no case of desaturation was recorded.

The optimal insufflation pressure that can ensure a compromise between effective ventilation without risk of hypoventilation and a lower risk of gastric insufflation was the main objective of the study by Bouvet and collaborators.

They compared 4 levels of insufflation pressure 10 vs 15, 20 and 25 cmH20 with simultaneous detection of gastric insufflation by stethoscope and gastric ultrasound. They concluded that the insufflation pressure at 15 cmH2O gives the least amount of gastric insufflation without the risk of hypoventilation for the patients.

Previous studies speak of a figure of 20 cmH2O but present several methodological biases [8,9].

In our study we chose an insufflation pressure of 15 cmH2O in the pressure-controlled mode. In manual mode the APL valve has been set to 15 cmH2O as well.

In our study, a respiratory rate of 12 breaths per minute was selected on the ventilator in volume and pressure controlled ventilation modes. In the manual ventilation mode, the operator took care to perform 12 breaths per minute.

In the other two studies, respiratory rate was determined at 15 breaths per minute.

A respiratory rate of 12-15 bpm with 100% FiO2 is commonly used for ventilating patients for general anesthesia.

In patients in the VM group, the volumes delivered to the patient at each insufflation were heterogeneous. This had a direct impact on the volumes of air passed into the stomach, which explains the higher incidence of gastric insufflation in this group.

In the VV group, despite the limitation to 7 cc/kg of the volumes delivered to the patient during each cycle, the incidence of gastric insufflation was also high.

In the VP group, the volumes delivered to patients during each cycle depend on the insufflation pressure set at 15 mmHg, this world appears more suitable, the rate of gastric insufflation in this group was the lowest.

Our data are comparable to those previously reported by Von Goedecke and et al. [9] and Mustapha M.Seed et al. where they showed that pressure-controlled ventilation reduces gastric insufflation compared to manual ventilation.

Cajander and et al. [10] compared the incidence of gastric insufflation during mask ventilation in pressure-controlled mode with or without PEEP. Moreover, they concluded that it is necessary to limit the levels of PEEP to decrease the incidence of gastric insufflation in pressure mode.

In our study we limited the PEEP to 5 mmhg.

The development of ultrasound in anesthesia and intensive care has made it possible to envisage the possibility of sonographically visualizing the gastric contents for the preoperative estimation of the gastric contents.

Ultrasound of the body of the stomach can allow a qualitative analysis of the state of gastric vacuity by direct visualization of the presence of water or food.

The ultrasound measurement of the antro-pyloric volume is not altered by the presence of air in the stomach, it is very reproducible and linearly correlated to the volume of the stomach.

Epigastric auscultation also makes it possible to assess the amount of air insufflated into the stomach during anesthetic induction, in a less precise way than ultrasound. However, this gastric insufflation detection method proved to be equally reliable in detecting even 5 ml of air insufflated into the stomach [11].

In our study, we used the auscultatory method. The same operator performed epigastric auscultation at the time of ventilation.

We had the advantage in this type of surgery of directly visualizing the volume of the stomach when the camera was introduced by the surgeon.

In the study by Mustapha M.Seed and al. the authors also used the auscultatory method.

The reduction of gastric insufflation during the induction of general anesthesia considerably reduces the risk of gastric aspiration which remains among the leading causes of death attributable to anesthesia even in scheduled surgery with a respected preoperative fast.

It also makes it possible to reduce the use of a gastric tube to empty the stomach before the start of surgery.

The risk of perforation of hollow organs during the introduction of laparoscopic trocars is a common complication in laparoscopic surgery and is prevented also by reducing gastric insufflation.

Minimal insufflated volumes provide the surgeon ultimate comfort and thus facilitate surgery and reduce the risk of per and post operative complications.

Among the limitations of our study, we can cite the use of the auscultatory method for the detection of gastric insufflation instead of ultrasound which has made considerable progress in recent years for the evaluation of gastric volume by measuring the antral area to the operating room but the visual evaluation by laparoscopic camera was an asset.

Thus, our study was limited to stable ASA 1 and 2 patients without a history of gastrointestinal pathologies or difficult intubation criteria.

5. CONCLUSION

Through our study we have demonstrated that the pressure-controlled ventilation mode causes less gastric insufflation without additional hemodynamic or respiratory cost and gives the surgeon greater comfort without the need for a stomach probe.

Further studies are needed to confirm our conclusions.

CONSENT

Patients were informed and consented to the study preoperatively.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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