Evaluation of the positioning of the tip of the Veress needle during creation of closed pneumoperitoneum in pigs[1]

Avaliação do posicionamento da agulha de Veress durante o estabelecimento do pneumoperitônio pela técnica fechada em porcos

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ABSTRACT

Purpose: Erroneous punctures and insufflations are frequent with the use of the Veress needle. Mistaken injections of gas in the preperitoneal space are not rare. The purpose of this research is to evaluate the correct positioning of the tip of the needle during creation of pneumoperitoneum. **Methods**: The needle was inserted into the peritoneal cavity. Tests to assess the positioning of the needle tip were carried out. Pressure, flow rate and volume were periodically recorded and the needle was removed, being immediately reinserted into the right hypochondrium and placed in the preperitoneal space. **Results**: The liquid flow test was always positive in the peritoneal cavity. No resistance to saline injection into the peritoneal cavity was observed, but increased resistance to saline injection into the preperitoneal space was observed in 45.5% of the cases. Some saline was recovered in 63.5% of the cases in the peritoneal cavity, and in 54.5% in the preperitoneal space. Saline drop test was positive in 66.6% of the cases in the peritoneal cavity and in 45.5% in the preperitoneal space. In the peritoneal cavity, initial pressure lower than 5 mm Hg was observed, and this pressure gradually increased during 123 seconds until reaching 15 mm Hg. In the preperitoneal space, initial pressure was 15 mm Hg. **Conclusions**: Aspiration, liquid flow and saline drop tests are important, whereas recovery test is inconclusive. Initial pressure of approximately 5 mm Hg indicates that the tip of the needle is in the peritoneal cavity. The peritoneal cavity should hold ten times as much volume of gas as the preperitoneal space. The increase in pressure and volume in the peritoneal cavity can be predicted by statistics.

Key words: Laparoscopy. Surgical procedures, operative. Pneumoperitoneum, Artificial. Punctures. Models, Animal.

RESUMO

Objetivo: Estabelecer parâmetros fidedignos do posicionamento adequado da agulha de Veress na cavidade peritoneal durante o estabelecimento do pneumoperitônio pela técnica fechada**. Métodos**: Em 11 porcos a agulha foi introduzida na cavidade peritoneal através do hipocôndrio esquerdo. Provas de posicionamento da ponta do instrumento foram efetuadas. Insuflou-se CO2 e registraram-se periodicamente pressões, fluxos e volumes. A posição intraperitoneal da agulha foi confirmada e esta foi retirada, sendo re-introduzida no hipocôndrio direito e posicionada sob visão direta no espaço pré-peritoneal. Os mesmos parâmetros foram aferidos. **Resultados**: A prova do escoamento foi sempre positiva no peritônio. Não se encontrou resistência à introdução de soro no peritônio em nenhum caso, mas sim em 45,5% dos casos no pré-peritônio. Soro algum foi recuperado em 63,5% no peritônio e em 54,5% no pré-peritônio. O gotejamento fluiu livremente em 66,6% das vezes no peritônio e em 45,5% dos casos no pré-peritônio. No peritônio, pressões iniciais de 5,20 mmHg aumentaram progressivamente durante 123 segundos até atingir 15 mmHg. No pré-peritônio a pressão inicial foi de 15,60 mmHg e oscilou entre 12 e 15,60 mmHg. O volume de gás injetado no peritônio foi de 1500 ml e de 100 ml no pré-peritônio. **Conclusões**: Aspiração e observação do escoamento e do gotejamento são importantes; recuperar ou não o soro é inconclusivo. Pressão inicial d" 5 mm é indicativo da ponta da agulha no peritônio, onde devem caber dez vezes mais gás que no pré-peritônio. No peritônio os aumentos das pressões e dos volumes pode ser previstos mediante estatísticas.

Descritores: Laparoscopia. Procedimentos cirúrgicos operatórios. Pneumoperitônio Artificial. Punções. Modelos Animais.

Introduction

The establishment of pneumoperitoneum is the most critical procedure in videolaparoscopy[1], and there is no consensus with regard to the best method of gaining access to the peritoneal cavity in such procedure[2]. The closed technique, performed by insertion of the Veress needle[3] into the abdominal wall, is the most widely used method[4]. Nevertheless, during the insertion of the needle, the exact location of the tip is not always clear, and erroneous punctures and insufflations are frequent[5-14]. Mistaken injections of gas in the preperitoneal space are not rare. Several subjective tests are taught in textbooks[15-17] to ascertain the positioning of the tip of the needle inside the peritoneal cavity before insufflations, such as liquid flow, aspiration, saline drop, injection and recovery tests. It has been observed that the tests performed with the tip of the Veress needle inside the preperitoneal space may partially mimic the results of the tests in the peritoneal cavity. It is necessary to carry out methodologically adequate studies so as to determine the real accuracy of these subjective tests. Pressure level, gas volume and gas flow rate during insufflations are objective parameters, which may be related to the actual location of the needle at any given moment during the procedure. However, such relations have not yet been established, in spite of being of great value in order to guide the surgeon through the crucial moment of the creation of a pneumoperitoneum. The objectives of this research are:

1. To evaluate the accuracy of the tests currently taught to confirm the correct positioning of the Veress needle in the peritoneal cavity.

2. To find reliable and predictable values of pressure, flow rate and volume of gas at any given moment during the establishment of the pneumoperitoneum by means of the closed access technique.

Methods

Eleven pigs of the Large White race, of both sexes, weighing around 15 to 20 kg, and aged around 50 to 60 days, were used in this study. After food fasting for 18 hours and water fasting for 8 hours, the animals were submitted to narcotic anesthesia by means of curarization and orotracheal intubation, and were maintained under intermittent positive breathing pressure. Said animals were placed in the supine position with the head elevated 20 degrees. An oral gastric tube was placed, and the stomach contents were aspirated. The researcher stood on the animal's right side and the first auxiliary, on the left. The Electronic Dyonics Insufflator was set at a flow rate of 1 liter per minute and a maximum pressure of 15 mm Hg. The Veress needle was inserted into the abdominal wall, in the left subcostal region, 3 cm from the midline, through a skin incision of 1.2 mm. The tip of the needle was pressed against the aponeurosis of the rectus muscle, and physiologic saline was placed into the needle. The liquid flow test was then performed, and consisted in observing whether the solution previously placed into the Veress needle would disappear at the moment of needle insertion. This test was considered positive when the liquid quickly disappeared as the tip of the instrument reached the peritoneal cavity. Subsequently, further tests were performed to ascertain the position of the needle (aspiration test, injection test, recovery test, saline drop test and initial pressure). All the tests were considered positive if they indicated that the needle was inside the peritoneal cavity, and negative, if otherwise. Aspiration was performed using a syringe attached to the Veress needle. This test was considered positive when no material was aspirated. After that, a total of 5ml of saline were injected through the needle. This was called injection test, and was considered positive if no increase in the expected resistance to liquid flow occurred. An attempt to aspire the saline infused was made. This was called recovery test, and was considered positive in cases where the liquid was not recovered. Drops of saline were poured into the Veress needle and the liquid flow was observed as the abdominal walls were lifted up. This was called saline drop test, and was considered positive when the liquid disappeared immediately. Afterwards, the needle was attached to an insufflator and the equipment was turned on, observing the initial pressure obtained. If the initial pressure was lower than 5 mm Hg, this test was considered positive, and insufflation continued. Instant pressure, instant flow and injected volume were recorded every 10 seconds until intraperitoneal pressure reached 15 mm Hg. Then, a 30-degree laparoscope was introduced into the supraumbilical region through a 10 mm port in the midline. The actual positioning of the Veress needle tip was observed in the peritoneal cavity (Figure 1).

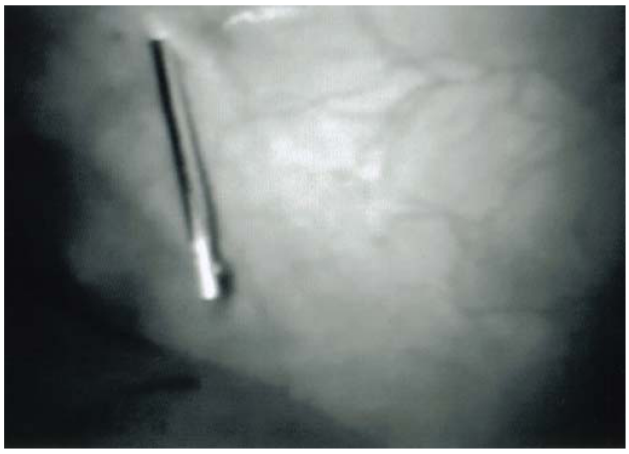

FIGURE 1 - Video-laparoscopic view of the peritoneal cavity showing the correct insertion of the Veress needle.

The instrument was then removed. A 1.2 mm incision was made in the right subcostal region, and the needle was perpendicularly introduced into the preperitoneal space, under visual control via the 30-degree laparoscope which had been introduced through a port located in the umbilical region (Figure 2). The pneumoperitoneum was then exhausted, the laparoscope was removed and tests to determine needle positioning (except for the liquid flow test) were performed. These tests were the same as those

performed to confirm the position of the Veress needle in the peritoneal cavity, and were also considered positive or negative. Subsequently, the needle was attached to the insufflator tube and the carbonic gas insufflator was set at a flow rate of 1 liter per minute and maximum pressure of 15 mm Hg. Numeric parameters (pressure, flow, volume) were checked every 10 seconds.

FIGURE 2 - Video-laparoscopic view of the Veress needle protrusion in the preperitoneal space, where the projection of the inner surface of the peritoneal serosa can be observed.

The pneumoperitoneum was re-established by means of the trocar located in the umbilical zone, and the 30-degree laparoscope was re-introduced. We checked whether the needle was still in the correct place, and whether peritoneal tears were present, inadvertently caused by the tip of the Veress needle. In order to study the relationship between pressure, volume and time, curve fitting software was used.

Results

In the peritoneal cavity, the liquid flow test was positive in all animals. During the aspiration test, nothing was aspirated when the needle was in the preperitoneum in 100% of the cases. The same occurred in only 83.3% of the cases with the needle in the peritoneal cavity, because in some experiments there was aspiration of gastric content, blood and hepatic tissue. During the injection test, no increased resistance was observed when 5 ml of saline were inserted into the peritoneal cavity. On the other hand, there was resistance to injection into the preperitoneum in 45.5% of the cases. In the recovery test, nothing was recovered in 63.6% of the cases in which the needle tip was inside the peritoneal cavity. The same occurred in 54.5% of the cases in which the needle tip was inside the preperitoneum. The saline drop test was positive in 66.6% of the experiments performed in the peritoneal cavity, and in 45.5% of those performed in the preperitoneum (Table 1). Initial mean pressure was 5.23 mm Hg in the peritoneal cavity, and 15.6 mm Hg in the preperitoneal space. Mean pressure values in the peritoneal cavity varied progressively until the pressure limit was reached. This progression lasted an average of 122.70 seconds. Mean pressure values in the preperitoneum ranged between 12 and 15.6 mm Hg, and the experiment lasted an average of 28.2 seconds (Figure 3). A progressive increase in mean volume in the peritoneal cavity was also noted (Figure 4). The mean total volume in the peritoneal cavity and in the preperitoneum was 1.5L and 0.1L, respectively.

TABLE 1 - Positive percentage (%) of Veress needle location tests in the peritoneal cavity and in the preperitoneal space.

TESTS	PERITONEUM (%)	PREPERITONEUM (%)
Liquid flow	100	Not done
Aspiration	83.3	100
Injection	100	45.5
Recovery	63.6	54.5
Saline drop	66.6	45.5

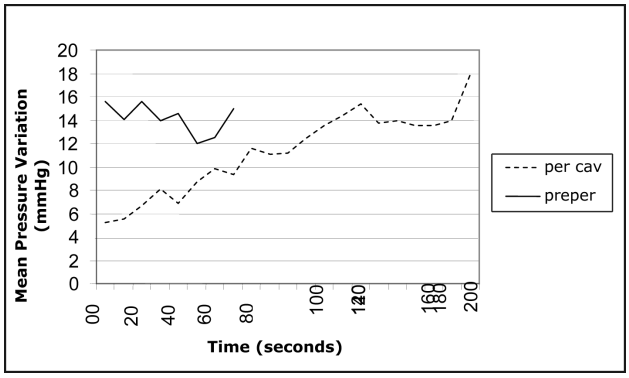

FIGURE 3 - Variations in mean pressure values (mmHg) in the peritoneal cavity (per cav) and preperitoneum (preper).

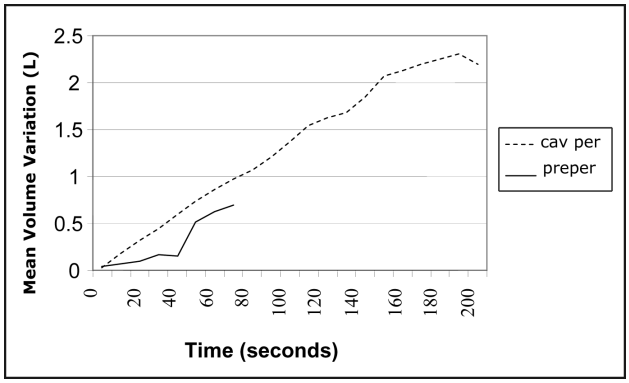

FIGURE 4 - Mean volume variation in the peritoneal cavity (cav per) and preperitoneum (preper

Discussion

Research articles usually focus on vascular and visceral injuries that occur during the creation of the pneumoperitoneum caused by the Veress needle and the first trocar[18]. However, studies of the prevalence of injuries caused exclusively by the insertion of the Veress needle are lacking. The closed technique currently used for the creation

of a pneumoperitoneum lacks objective parameters to assess the correct positioning of the needle. One of the purposes of this research was to establish expected values for dependent variables (intraperitoneal pressure at any given time and gas volume injected throughout the procedure) in function of an independent variable (time), and to express this relationship mathematically, defining an equation that incorporates these variables. Thus, surgeons will be able to count on objective data during the process of creating the pneumoperitoneum. It is absolutely fundamental that the flow rate be pre-set on the insufflator at one liter per minute. This does not constitute a hindrance to surgical effectiveness, as the Veress needle diameter itself allows a maximum flow rate of 1.4 liters per minute. This variation in flow rate should have little influence on the total amount of time for peritoneal insufflation to final pressure levels adequate for most interventions, usually of 12 mm Hg. An important observation, confirmed during the experiments, should be made before analyzing the results obtained from positioning tests (Table 1). During insertion of the Veress needle, it was observed that the peritoneum of pigs behaved with considerably greater elasticity than the human peritoneum. This was only confirmed because of the practical laparoscopic knowledge of various members of our team. Therefore, for the analysis of the positioning tests, it is important to have in mind this apparently higher elasticity of the porcine peritoneum. The liquid flow test always showed the correct location of the needle in the peritoneal cavity. Thus, a negative test should be a good indication of incorrect needle positioning. Nevertheless, it cannot be inferred that positive results always indicate the correct positioning of the needle, because the liquid may flow freely even if the tip of the instrument is in the preperitoneum (false positive). Therefore, our study cannot warrant the specificity of this test. A negative injection test can also be a good indication of inadequate needle positioning. Recovery and saline drop tests were not very useful to indicate the location of the needle or whether its positioning was adequate or not. We can conclude that the subjective tests currently taught are still insufficient to adequately guide the surgeon through the creation of a pneumoperitoneum one of the most crucial moments during laparoscopy – because only the liquid flow and injection tests performed in our study indicated the incorrect positioning of needle tip in the peritoneal cavity. The mean initial pressure observed in the peritoneal cavity was within the expected range described in books[15-17]. Initial pressure was found to be a reliable parameter with regard to correct positioning of the needle. This was due to a pronounced difference between the pressure in the abdominal cavity and the pressure in the preperitoneum. Only one animal in which the experiment was performed in the preperitoneal space presented initial pressure lower than 8 mm Hg. Therefore, initial pressure lower than 8 mm Hg suggests that the needle is probably inside the peritoneal cavity. With regard to the increase in pressure as a function of time, it was confirmed that pressure increased linearly with time in the first 80 seconds when the needle tip was inside the peritoneal cavity. Such increase can be estimated by applying the following formula: $y = 4.4059 + 0.0831\ x$, with y = pressure (mm Hg) and x = time (seconds). It is also possible to devise a formula to calculate the increase in pressure in the preperitoneum, but this formula is bound to be less valuable than the one for the intraperitoneal cavity, because of its lower coefficient of reliability. More important than the creation of a formula to calculate the increase in pressure in the preperitoneum was the confirmation that the pressure progressively decreased in the first 30 seconds, which means that the initial pressure was high and progressively decreased in 30 seconds. There are no reports in the related literature of the increase in volume of CO_2 insufflated during the creation of the pneumoperitoneum. In our study, we confirmed that the increase in volume when the needle was in the peritoneal cavity was not linear during the initial 80 seconds. This also proved to be a more reliable parameter than the observation of the increase in pressure, because of the higher reliability coefficient ($r^2 = 0.996$). In the preperitoneal space, the observation of the increase in volume is also a more reliable parameter than the observation of the increase in pressure. The present study demonstrated that surgeons should pay more attention to volumetric increase, since it is a reliable parameter, according to the following formula: $y = 0.0590 + 0.0134\ x$, with y = volume (liters) and x = time (seconds), when the tip of the Veress needle is in the peritoneal cavity.

Conclusions

It can be concluded from this study that only the liquid flow test and the injection test can be indicators that the tip of the Veress needle is positioned inside the peritoneal cavity. However, variations in intraperitoneal pressure and in gas volume during insufflation are sufficiently reliable parameters to ascertain the intraperitoneal positioning of the tip of the needle.

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