The pneumoperitoneum – a continuing mistake in laparoscopy ?

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Preface

Today, laparoscopic surgery is an integral part of the operative repertoire and has broadened gynaecological surgery by continuously providing new indication areas. For a long time, laparoscopy was regarded as the major trend of the century and as a revolution in surgical technology. In recent times, however, the problems associated with this operating technique have been subject of discussions. After an enthusiastic phase, including also an analysis of the technique, the reality of applying this operating technique in the daily hospital operation has now arrived.

Side effects caused by carbon dioxide

Whilst instruments and devices have become more advanced, the principle of the CO_2 pneumoperitoneum has not changed for decades. And it is precisely the carbon dioxide which limits the scope of this operative technique. The occurrence of possible side effects and complications is more significant in case of older and higher risk patients and longer operations. Problems of the CO_2 laparoscopy such as hypothermia with increased post-operative pain but also haemodymic and metabolic effects such as a CO_2 absorption and a CO_2 intravasation coupled with an increase in pCO_2 have been described (1,2). The result can be a metabolic acidosis and a hypercapnia as well as a hypoxaemia in the tissue (3, 4, 5,6). The pneumoperitoneum itself leads to an increase of the intraabdominal pressure with a consecutive elevation of the diaphragm which can result in hyperventilation. The compression of the V. cava causes the heart output volume to be reduced and the central venous pressure to be increased, resulting in increased vascular resistance in the arterial circulation (7, 8, 9, 10). With the increased popularity of the operative laparoscopy, increase in indications with longer operating times and operations on older patients or higher-risk patients, more and more reports about acute organ failure (8) or fatal complications caused by carbon dioxide insufflation (9, 10, 11) are received from anaesthetic and intensive care departments. This in turn results in statements such as that minimal invasive surgery is maximal invasive from a physiological point of view and that consequently patients subjected to endoscopy should be carefully selected (8, 9, 10, 11).

Operative complications and counterindications

Complications during as blind insertion such as vascular lesions or intestinal injury occur relatively seldom, can however be serious. Also a pneumothorax, a pneumomediastinum, a pneumoopericardium, an air embolism or a massive subcutaneous emphysema could result (12, 13). Absolute counterindications of the laparoscopy using pneumoperitoneum are cardiac insufficiency and lung obstruction whilst relative counterindications are pregnancy, diaphragmatic hernia and Adipositas per magna. During endoscopic surgery, lasting several hours, more than 100 litres of cold carbon dioxide may circulate through the abdominal cavity, causing hypothermia; the body temperature can sink down to $3^{o}C$ during this process.

Apart from possible complications caused by the carbon dioxide gas, problems with the pneumoperitoneum in laparoscopic surgery should also be mentioned. Each surgeon knows about the dangers of a collapsing pneumoperitoneum at the moment a haemorrhage occurs. In most cases, the suction irrigation system also fails, making it impossible to see the area whilst the surgeon tries to pinpoint the haemorrhage using suction and irrigation. As a result of the escaping pneumoperitoneum, the room in the upper abdomen is lost (reservoir for intestinal loops), causing the intestines to move back from the upper abdomen into the pelvis and the just pinpointed haemorrhage once again disappears out of sight. If the spraying vessel then covers the lens system which, anyway, is constantly misted up (temperature difference between the irrigation solution and the body temperature, the surgeon will

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experience the first signs of confusion. It is also nearlv impossible to grasp the bleeding vessel with the tiny ends of a laparoscopic forceps or even ligate the vessel so that a complete confusion and conversion to open surgery can hardly be avoided.

A further problem of CO_2 laparoscopy is a possible contamination of the carbon dioxide with viruses, bacteria, rust, metal dust, Teflon (14) in the insufflation device or the hose system. This problem occurs, in particular, in countries in which it is not usual to produce medical carbon dioxide. Recent studies by Koninckx in Leuven showed in animal trials that, depending on the duration of the operation, CO_2 aids the formation of adhesions. To complete the picture, one should also mention the studies of various work groups carried out on animals to solve the problem of the spreading of malignant cells, apparently caused by the modulation (acidosis) of the peritoneum by the CO_2 gas (15).

This beckons the question: Why is the endangering and hazardous carbon dioxide gas not removed from the concept of the minimal invasive surgery using laparoscopy?

“Laparoscopic market” vs. cost-conscious problem solving

The continuously increasing costs are mainly the result of both industry and doctors attempting to solve the problems of the pneumoperitoneum with the aid of technical devices. When sterilisation was one of the main operational treatments, emphasis was placed on the development of gas-tight trepans, cold light sources and insufflation devices. With endoscopic surgery becoming more and more complicated, special instruments with turnable and rotating parts, mimicking the freedom of the hand movement, were designed. As adequate suture techniques could not be applied during laparoscopy a special thread material and sophisticated stitching machines were quickly developed specifically for this purpose. These items had, of course, to be developed as disposable items, allowing the development costs in the rapidly developing laparoscopic market to be recovered. Complications during laparoscopy, i.e. during blind insertion were, as today, resolved with the development of special “safety trepans” which, of course, had to be disposable for the aforementioned reasons. In order to solve the gas loss problem and the associated problems of loss of visibility caused by an insufficient pneumoperitoneum, industry developed modern high-flow insufflators, additionally warming the gas up to body temperature to prevent hypothermia. The rising costs of the laparoscopic surgery are at least met today by industry producing reusable systems. With the aid of surgeons and professionally developed designs, marketed with strong financial backing, an actual “laparoscopic market” has emerged; industry is developing faster and faster systems, vehemently announced and promoted in endoscopic journals or on endoscopic congresses under the headlines of “Initial findings ...” which are generally not followed by any further findings. One should, however, not forget important developments such as mono and bipolar high-frequency coagulation systems, argon gas coagulation, endocoagulation, laser systems or ultrasound measuring devices, which can also be used in open surgery.

Modern developments contain multi-functional instruments and miniaturisations of optical and instrumental systems. Also the tactile sense which was lost as a result of the use of long instruments, has been regained with the use of special microprocessor systems. On the basis of Albert Einstein’s principle “Everything should be made as simple as possible but not simpler”, the areas of tele-medicine and robotic medicine, in particular, showed an extremely progressive development. During daily surgical routine operations, however, not even a simple voice-control manipulation of the arm holding the camera has managed to establish itself. As part of these developments, the range of available equipment is expanded with further high-tech devices which, in case of incorrect functioning could cause confusion. Governments and countries offer enormous financial subsidies to visionaries dedicating themselves and their lives to the development of these systems and which in future will provide the profession of medical engineer, operating on virtual locations with the aid of a joystick.

Facing increasing costs for the Health Service and more and more demands for cost efficiency, we must ask ourselves: why is the carbon dioxide pneumoperitoneum - as a cause of the cost explosion - not eliminated from the laparoscopic concept? Based on the above, a further question arises: Is the concept of the carbon dioxide pneumoperitoneum still justifiable from the physiological, surgical and economical point of view?

Gasless laparoscopy - a solution to the problem or rather - a prevention of the problem?

Gasless laparoscopy continues to pursue the concept of a minimal invasive operating method, however, offering the principle of simplification, cost-effectiveness and a wide range of application. This technique is based on the principles of minimal invasive operating methods, combined with the conventional technique used by “open” abdominal surgery. This gasless technique reduces all of the aforementioned disadvantages, risks and complications of gaseous endoscopic surgery to a minimum, retains, however, all advantages of the laparoscopy such as little scars, better appearance, less pain, quicker recovery, shorter hospital stays, etc. The method thus offers progress (the combination of the latest techniques of endoscopic surgery) by taking a step back (proven and established, conventional abdominal surgery techniques).

Why has gasless laparoscopy so far had a negative image? A comparison of studies

Gasless laparoscopy has so far faired badly in randomised studies. In our opinion, past clinical studies have, however, awarded low marks to the gasless laparoscopy as the target and definition criteria were not correctly selected or the design used in the study could not even withstand an examination. The study by Johnson and Sibert (16) uses a sterilisation as a comparative intervention. It is not described, how much experience the authors were able to gain in the use of the gasless technique prior to the study.

Fig. 1: Representation of an evenly stretched, dome-shaped abdominal cavity when using a pneumoperitoneum (left) compared to the gasless laparoscopy using systems with extendable retractors (i.e. LaparoLift system).

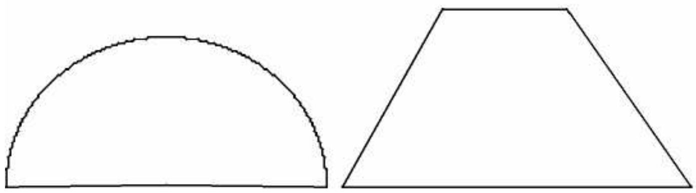


Fig. 2: A collection of disposable items required for carrying out a gas less laparoscopy, using the LaparoLift system.

If the scientists had been adequately versed in the gasless technique, they would surely not have selected a sterilisation as a comparative intervention as significant advantages with regard to physiological side effects, are only apparent from interventions lasting more than 30 minutes. The fact that the study was furthermore stopped because of technical difficulties, bad visibility and longer operating times shows that the researchers were inexperienced in the use of gasless laparoscopy at the start of the study. Similar conclusions are derived at by the authors of another randomised study carried out during fertility operations (17). The authors of this study also used the LaparoLift system which had to produce primarily bad results with regards to an all-round visibility, as the abdomen is only partially extended in a tent-like shape (Fig.1).

The following studies show at least the same result for both methods for one of the examined parameters: As part of a randomised study, which mainly served to examine post-operative pain when using cold or warmed CO_2, a parallel pilot study carried out on 15 patients - aiming to establish post-operative pain - compared gasless laparoscopy and a CO_2 pneumoperitoneum (18). No information about procedures or duration of the operation were provided with the study. Again a LaparoLift was used when operating on the patients. The conclusion states that with regard to post-operative pain, gasless laparoscopy did not differ from the group operated with cold CO_2. The randomised study of Guido et al. (19) established the same results. The study showed that in 67 patients with tubal ligation, gasless laparoscopy produced similar results with regard to post-operative pain.

If one, however, looks at experimental studies, these show that gasless laparoscopy offers clear advantages compared to pneumoperitoneum laparoscopy. A randomised study about renal excretion and the electrolyte metabolism during gasless interventions and gas laparoscopy carried out on pigs (20) showed that a significant reduction of creatinin clearance and urinary excretion occurred during and after the CO_2 laparoscopy. Also, a significant increase in the serum aldosterone occurs, an indication of a disorder of the renin-angiotensin system due to the underperfusion of the kidneys, causing a reduction of the sodium and potassium level in urine. Apart from other physiological advantages of gasless laparoscopy discussed in this study, the authors concluded that gasless laparoscopy clearly offered better results than gaseous laparoscopy with regard to the renal haemostasis. To increase the safety of laparoscopic surgery, the authors even recommended to monitor the urine electrolyte and the urine volume during a gas laparoscopy process and, in particular, in case of longer operations. Another experimental study by Woolley et al. (21) carried out on pigs, clearly showed that gasless laparoscopic surgery also achieved a significantly better pulmonary and systemic haemodynamic compared to a CO_2 pneumoperitoneum.

Gasless laparoscopy based on reusable systems

Gasless laparoscopy was described in the 90´s by several authors using different systems (overview in 22). Around 1990, the gasless method using the so-called LaparoLift was launched by a company (Origin), which intended to quickly recover the high development costs by only making disposable items available. The right technology but wrong approach: On one hand, costs were to be saved by using conventional instruments whilst on the other hand, disposable items (i.e. Laparo fan) had to be used in order for the system to work (Fig. 2). The purchasing costs of the electrical high-tech lifting device are also extremely high. Furthermore, the LaproLift can generally not be adequately used as the all-round visibility is inadequate in comparison to the pneumoperitoneum as with this method, a “tent-shape” is formed (Fig. 1). Apart from the LaparoLift, nearly all other abdominal wall retraction systems used for gasless laparoscopy (23) suffer from this disadvantage. Origin’s aggressive actions supported by an elaborate PR campaign meant, however, that this system using gasless laparoscopy has become relatively well known. Where reference is made to gasless laparoscopy, this form of surgery is today automatically associated with the use of the LaparoLift. The relatively high purchase price and subsequent costs, the poor all-round visibility and the unsatisfactory performance of the LaparoLift in many studies meant that the gasless laparoscopy itself received a bad image, so that the gasless technique is only used sparingly today.

If one thinks, however, about the actual and correct concept of gasless laparoscopy, the purpose was really to develop reusable systems, offering an adequate all-round visibility (24). The author himself has been involved in two developments. Together with the Karlsruhe Research Centre, the system AbdoLift (Fig. 3) was developed between 1996 and 1997 which has become part of the product range offered by Storz. The system is reusable and consists, in contrast to the LaparoLift system, of three retractors which, after insertion, are intra-abdominally spread to lift the abdominal wall. The disadvantage of the poor all-round and upper abdomen visibility remained and the retractor system consisted furthermore of approx. 19 components whose assembly was not unlike solving a jigsaw puzzle (Fig. 3, right).

The AbdoLift system (Fig.4) developed together with STORZ between 1997 to 2000 consists, in contrast, of two retractors inserted intra-abdominally and which joint together result in an anatomically shaped rectangle, convexly bending downwards (Fig. 5). The retractors are arranged in such a way that after intra-abdominal positioning, the rectangle can also be moved into the midabdominal region to lift the upper abdomen (Fig. 6). This ensures, similar to the pneumoperitoneum, the correct opening up of the reservoir for intestinal loops in the upper abdomen (Fig. 7) which is also achieved by the 30^{o} Trendelenburg positioning (Fig. 8) so that visibility in the lower abdomen is - like during the pneumoperitoneum laparoscopy - not impeded (Fig. 9). The two parts of the abdominal wall retractor are individually inserted into the abdominal cavity via an incision in the lower umbilical fossa. The parts are then connected and fixed to a mechanical lifting arm (Fig. 10), holding a device in which a spring balance, measuring the force exerted on the abdominal wall, is integrated. The retractors are available in different sizes and designs, so that the retractor can be adapted to the anatomy of the patient.

Fig. 3: The AbdoLift system, a reusable abdominal wall retraction system. Developed in co-operation with Forschungszentrum Karlsruhe and today offered as part of the product range of Storz.

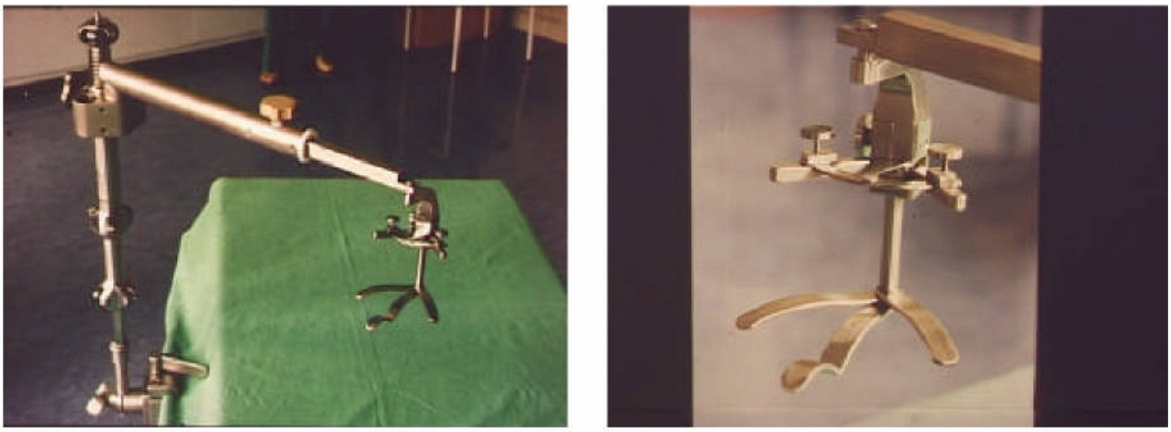


Fig. 4: The VarioLift system, a reusable abdominal wall retraction system, put together on the right side of the operating table at shoulder height. The arms of the patient are already positioned on both sides and the sterile cover is already in place.

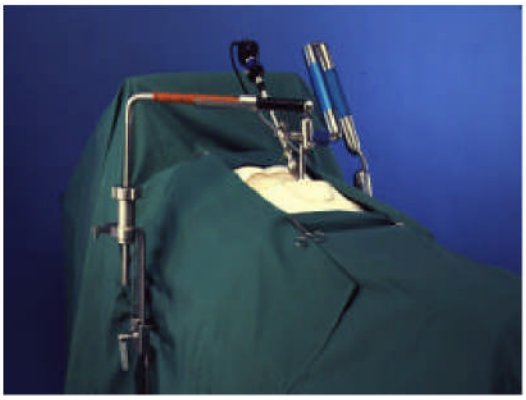


Fig. 5: The VarioLift system, consists of seven non-wearing parts, the table holder with its extension, a spring balance and anatomically shaped retractors, inserted intra-abdominally.

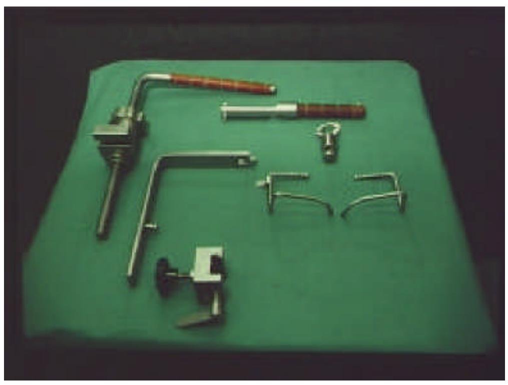


Fig. 6: The VarioLift system: After intra-abdominal insertion, the retractors also unfold in the upper abdomen.

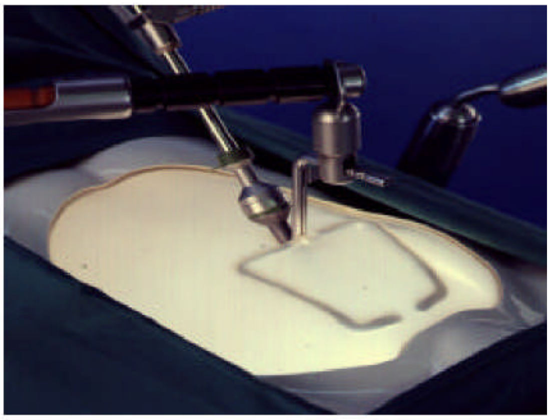


Fig. 7: The VarioLift system: The unfolding of the upper abdomen allows the inspection of the liver as during a pneumoperitoneum laparoscopy.

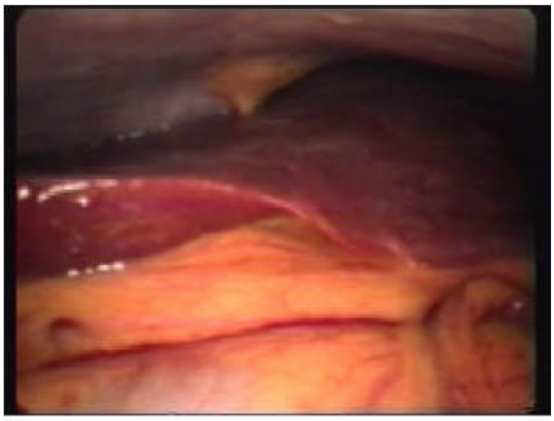


Fig. 8: The VarioLift system: The even unfolding of the upper abdomen and the 30° Trendelenburg positioning assists the movement of the intestinal loops into the upper abdomen

Tab.1: Number and type of gasless laparoscopy carried out between 1990 and 2000 (n = 1039). Hysterectomy = gasless laparoscopic total hysterectomy; Endometriosis = severe forms

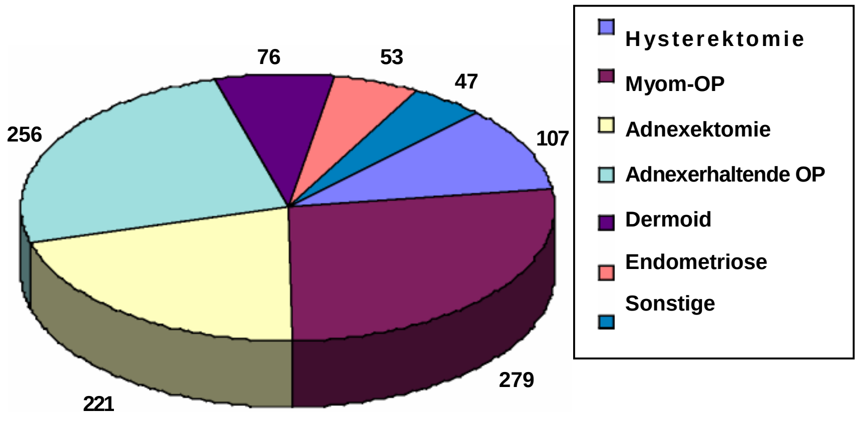


Fig. 9: The Variolift system: The reservoir forming as a result of the upper abdomen unfolding, accommodates the intestinal loops, allowing unimpaired visibility in the lower abdomen. The structures - in this case the ureter - can be shown as when using the pneumoperitoneum system.

Fig. 10: The VarioLift^{Gyn} system: After intra-abdominal insertion, the retractors are connected and attached to the mechanical lifting arm, containing a device in which a spring balance for measuring the force exerted on the abdominal walls, is integrated.

Fig. 11: The VarioLift system: In order to insert the instruments, two 12 mm suprasymphysary incisions are made below the pubic hairline and flexible rubber sleeves are put into position via which instruments can be inserted.

Fig. 12: The VarioLift system: Some of the instruments specially modified for the gasless technique are double hinged (i.e. needle holder) allowing also an opening deep in the abdomen.

In order to insert the instruments, two 12 mm suprapubic incisions are made below the pubic hairline (Fig. 11). Via flexible rubber sleeves, nearly all conventional instruments such as Wertheim clamps, scissors, sponges, etc. can be inserted in addition to instruments modified for the gasless technique.

Experience with gasless laparoscopy interventions

The author has nearly ten years experience in the use of gasless laparoscopy. During the last five years only the aforementioned reusable systems were used. Between October 1990 and February 2000 we carried out 1039 gasless laparoscopy surgical interventions (Tab. 1). During the last two years and after nearly seven years experience with gasless laparoscopy and continuous analysis and improvement of the currently used method, it was time to support the positive results and experience with a prospective study. Between 1998 and 1999, a prospective study was carried out during adnexa interventions. These interventions are particularly suited for a comparative study as during these interventions, normally only the access changes, whilst the intra-abdominal procedure can be standardised. The study included organ retaining interventions as well as ovariectomies and adnexectomies. In order to make it even easier to compare the results, only ovariectomies and adnexectomies were used for the evaluation. This intervention is ideally suited for a comparative study as in the gasless group and in the gaseous laparoscopy, the mesosalpinx or the ligamentum infundibulopelvicum can be coagulated in a bipolar manner so that the intra-abdominal procedure is identical. Thus actually only the influence of the different access, i.e. that of the pneumoperitoneum and the gasless laparoscopy could be examined. The findings showed that with regard to operating time, there was no difference between interventions with or without gas. Patients which had been operated on using a gasless laparoscopy used slightly less pain-killer (perfusor pump with activating function) on the first post-operative day. The greatest difference was apparent with regard to shoulder pain: Whilst patients which were operated on without the use of gas only occasionally complained about shoulder pain which lasted for two days at the most, patients on which a carbon dioxide pneumoperitoneum laparoscopy was carried out experienced sometimes medium strong pain for up to five days and light pain in the neck/shoulder region for up to ten days. The study therefore showed that the time up to the full activity was approx. 30% longer when using pneumoperitoneum laparoscopy compared to gasless laparoscopy. These at least equal or better results compared with the gas laparoscopy were already established during interventions that only lasted approx. 45 minutes. As side effects manifest themselves in interventions with carbon dioxide insufflation lasting more than one hour which continue to affect the patient for approx. three hours after the operation (4), it can be assumed that in case of longer interventions, gasless laparoscopy will offer considerably less side effects.

Advantages of gasless laparoscopy for patients

As a result of not using a carbon dioxide pneumoperitoneum, patients will experience significantly less post-operative pain. Mainly the interfering pain in the shoulder and neck region experienced after endoscopic interventions using a carbon dioxide pneumoperitoneum is prevented or largely limited. In comparison to the pneumoperitoneum, laparoscopy patients require fewer pain-killing drugs. The recovery phase and return to normal activity is shorter than for laparoscopy interventions using gas and is only approx. two weeks after a hysterectomy.

The cosmetic result (Fig. 13) is also considerably better than these of pneumoperitoneum laparoscopy as the two incisions can be made directly above the symphysis and very close together as the degree of free movement offered by curved conventional instruments offers a larger radius. When using a gas laparoscopy, these incisions must be higher up (to be able to reach behind the uterus with the long instruments) and further apart (as the instruments are not curved).

The operation is safer and more precise as no long and undesirable instruments are required (Fig. 14) (23-30). When using the gasless method, a possible risk of infection due to inadequately cleaned endoscopic instruments and various hose and pump systems is eliminated. The system also eliminates serious complications resulting from a “blind” insertion as, in case of a gasless laparoscopy, the surgeon can look into the abdominal cavity.

Complications resulting from clamping and suture systems or electrical cauterisation, i.e. injury of the ureter during an endoscopic hysterectomy (31) are avoided. Also unforeseeable later complications from titanium clamps remaining in the body which still have to be investigated, are avoided.

Inadequate suture techniques often occurring during endoscopic treatment also do not represent a problem for the gasless technique, as conventional suture techniques using needle and thread (Fig. 15) can be used without problem. In particular when closing up the myometrium after the enucleation of an intramural myoma, endoscopic suture techniques often fail. As a result, the inadequate adaptation of the myometrium has been discussed as the cause for possible uterus ruptures during pregnancy and childbirth (32, 33, 34,35).

Fig. 13 Cosmetic result after a gasless laparoscopy using the VarioLift^{Gyn} system. Left a patient four weeks after a gasless laparoscopic myoma enucleation, right a patient six weeks after a gasless laparoscopic hysterectomy

Fig. 15: Wound closure after a myoma enucleation. Left: The myometrium is adapted

Fig. 14: Difference between the instruments used for the pneumoperitoneu m laparoscopy and conventional open surgery instruments (front and centre) as well as special instruments for the gasless laparoscopy (back).

with curved needle HR43s using a Maxon 1 thread. Right: Closure on the anterior wall adaptation.

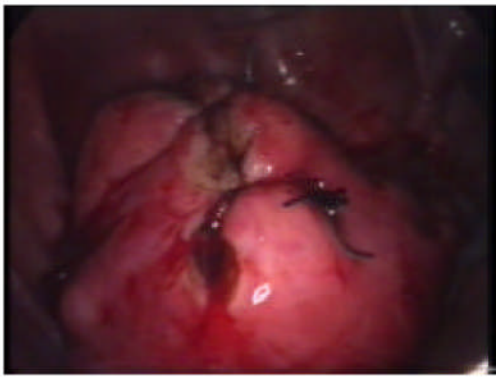


Fig. 16: Gasless laparoscopy under regional anaesthesia. Patient with dermoid tumour on both sides (left 3 cm, right 1 cm) two months post sectionem which was carried out externally on both sides because of a dermoid tumour. The dermoides could not be established during the sectio. Left intraoperative, right 15 minutes postoperative.

Also, all of the aforementioned side effects, risks and complications arising from the use of the carbon dioxide gas are eliminated so that apart from young and healthy patients also older or higher risk patients can be operated on using the gasless method. The technique also allows endoscopic surgery to be carried out under regional anaesthesia such as spinal anaesthesia or peridural anaesthesia (Fig. 16) which under CO_2 pneumoperitoneum would be problematic due to the high intra-abdominal pressure and the resulting pain and organ compression (diaphragm, pulmo, cor). For higher risk patients it is often only due to the use of a regional anaesthesia that an operative laparoscopy can be carried out.

Domenico D´Ugo, an anaesthetist based in Rome, stated the following during the "International Symposium for Gasless Laparoscopy in Gynaecology" staged in 1997 in Bochum: "The use of carbon dioxide is nearly the only reason for excluding high-risk patients which in actual fact would be just the persons profiting from a minimal invasive procedure...."

But also for young and healthy patients, laparoscopic surgery carried out under regional anaesthesia offers some advantages. There are, for instance, no direct post-operative side effects such as vomiting and ill feeling. Also operations during pregnancy, which so far have been a relative counter indication to the pneumoperitoneum laparoscopy are possible with the gasless method as the intra-abdominal pressure on the uterus and an acidosis of the foetus are prevented and surgery can be carried out without the need for a general anaesthesia.

Advantages for the surgeon

Hazardous and for the endoscopic surgery typical complications during the "blind" insertion of the Veres needle or of the first trepan, such as intestinal or vessel lesion are eliminated by this method offering visibility and using specially designed S-hooks. Apart from special also standard instruments used in open surgery can be used. Proven needle and thread techniques can be used for carrying out surgical sutures instead of the need for clamps and sewing devices or using coagulation, which are expensive or can cause complications (32) and whose advantages and benefits have so far not be shown. Conventional operating an preparatory techniques that have been proven over many years, refined, researched in studies and supported by experience and that are used in open surgery and have become the so-called Gold Standards can be used in the gasless laparoscopy without problem (Figs. 17, 18, 19). By using these operating standards in the gasless laparoscopy, there is no need to carry out a prospective and randomised study for every new laparoscopic operation indication to verify the effectiveness of the laparoscopic method. In contrast to the long endoscopic instruments, the conventional instruments retain the tactile feeling of the hand, allowing surgery to be carried out in a more precise and safer manner. The learning phase of this technology is also considerably shorter as only the hand-eye coordination from the working area to the monitor must be learned. The operating steps and technique are the same as when using an abdominal incision and are thus easier.

Gasless laparoscopy also simplifies the removal of samples and tissue from the abdominal cavity as these can be morcellated with a scalpel or scissors. As the organ or part of an organ is immediately removed, a loss of organ parts such as myoma is being counteracted. During a gas laparoscopic operation, the organ is in most cases removed at the end of the operation to prevent any gas losses through the extended opening during removal procedure.

Fig. 17: Use of conventional operative techniques during laparoscopy; here during a hysterectomy. Left: Separation of the lig. latum after double ligature. Right: Opening the vagina using a scalpel knife which can naturally also be used for the morcellation of tissue such as myoma.

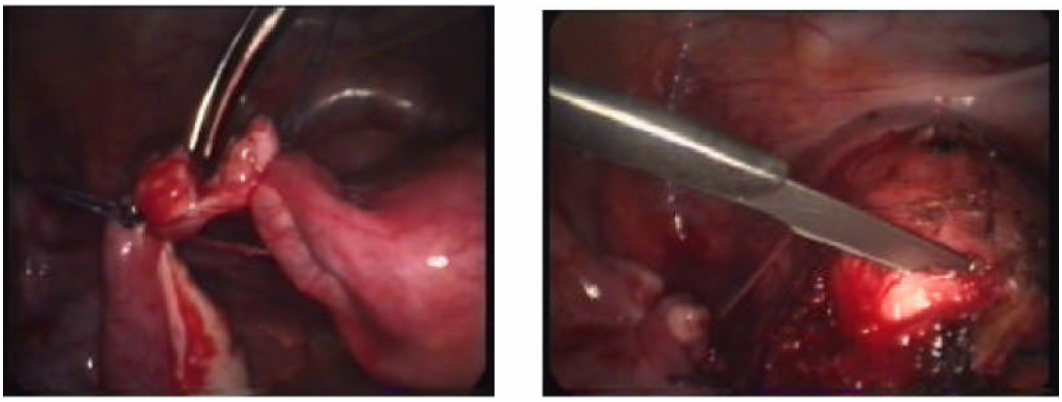


Fig. 18: Use of conventional operating techniques during a gasless laparoscopic hysterectomy. Left: Preparation of A, uterina left. Right: Ligature of the latter using Vicryl o and extracorporeal knot.

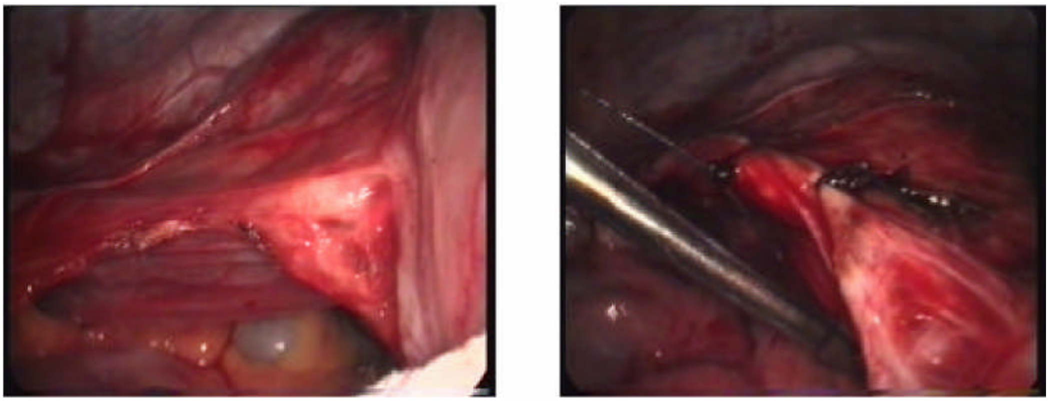


Fig. 19: Use of conventional operating techniques during a gasless laparoscopic hysterectomy. Left: Separation of the uterine vascular bundle left. Right: Laparoscopic sealing of the vagina.

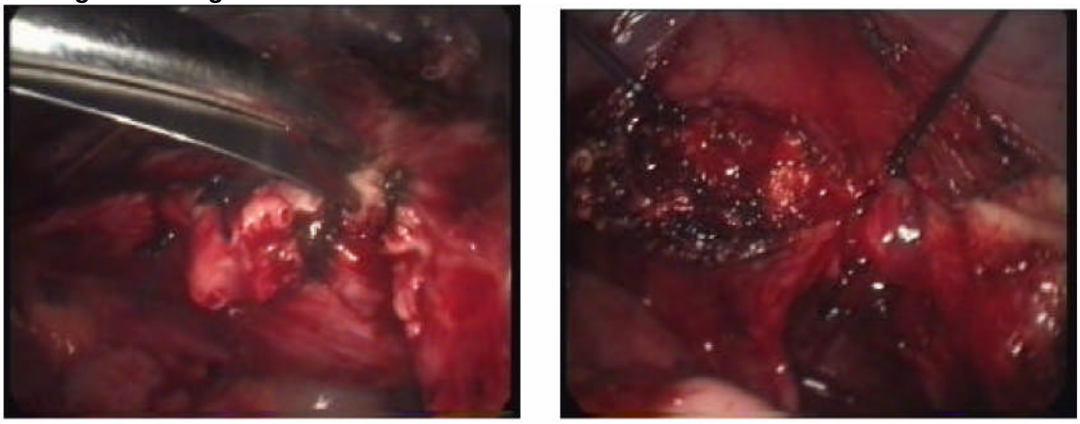
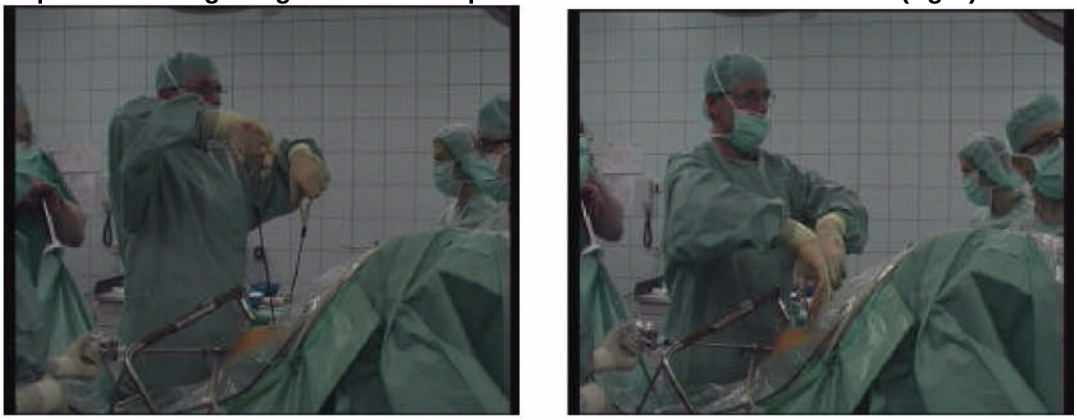


Fig. 20: Demonstration of the unphysiological posture adopted by a surgeon during a pneumoperitoneum laparoscopy using gas laparoscopy instruments (left) and during an operation using the gasless technique and conventional instruments (right).



As a result of permanent manipulation during subsequent steps of an operation, tissue parts can be moved and lost. The gasless method also eliminates the problem of the escaping gas. As no gas is lost after the opening of the vagina, a combined vaginal laparoscopy operation is possible. In particular during the so-called LAVH (laparoscopy assisted vaginal hysterectomy) which has become more popular in recent years, the loss of gas was an undesirable effect for which industry once again had to provide a solution with specially sealing vaginal manipulators. When using the gasless technique, the problem of the loss of the pneumoperitoneum does not arise even during a total hysterectomy and after opening of the vagina. Of particular importance for a total hysterectomy is the ability to use standard instruments and standard techniques for separating uterine ligaments and vessel structures (Figs. 17 - 19). As a result, complications can be avoided and costs can be saved (24, 25, 30, 31).

A decisive advantage of gasless laparoscopy is the ability to use effective suctioning, in particular, when working with a laser or during extensive coagulation. As a result and side effect of the minimum exsufflation which is connected to the insufflation tap of the optic trepan, the lens does not mist up. Compared to the gaseous laparoscopy, visibility is thus improved and one of the main confusion factors of laparoscopic operations is eliminated. Also any problems for the surgeon (36) caused by the rather unphysiological posture during a gas laparoscopic operation (Fig. 20) are prevented.

Advantages for the Health System

Minimal invasive laparoscopic operations with carbon dioxide are approx. seven times as expensive as the same operation using laparotomy (37). These costs are, however, balanced out by the shorter hospital stay so that, all in all, both operating methods result in a similar cost for the hospital (38). Minimal invasive gasless laparoscopic operations are, however, more cost-effective, as the systems making gaseous laparoscopic operations expensive are not required. Instruments can be cleaned as before and no special instrument washers are required. Conventional instruments also offer a significantly longer life than laparoscopic systems, resulting in less frequent repair and replacement. Gasless laparoscopy thus saves costs during the operation (compared to gas laparoscopy) and by shortening the hospital stay and recovery time (compared to the laparotomy) and provides a real economical benefit for the hospital and the Health Service. There is also no need for always using new instruments and developments produced by industry to increase and improve the safety and handling of a gaseous laparoscopy. The gasless method uses no items such as titanium clamps which are only used once and no special thread which is extremely expensive.

The technique is simple and can be easily learned, allowing more surgeons, which so far have not carried out endoscopic operations because of the difficulty involved, to now make use of this technique. As a result, more patients will be able to profit from the minimal invasive operating method. Bearing in mind the cost explosion in the Health Service, the gasless laparoscopy offers a cheaper alternative to pneumoperitoneum laparoscopy which can also be used in developing countries where local hospitals cannot afford expensive instruments and where, as a result, the spread of laparoscopic operating methods is only slow (39). Minimal invasive operating processes are, however, urgently required in these countries as patients are directly released from the hospital after the operation.

Disadvantages of gasless laparoscopy using AbdoLift

In case of expanded adhesions, the insertion of retractors is more difficult. If the upper abdomen does not contain any adhesions, the retractors can, initially, be inserted into the upper abdomen to carry out the adhesiolysis in the midabdominal region and partially in the lower abdomen. In some cases, adhesions in the midabdominal region and lower abdomen can also be removed using an initial low-pressure pneumoperitoneum, after which gasless laparoscopy can be used. Patients with a combination of being overweight (over 95 kg) and having a height of less than 155 cm cannot be operated on with the current models as the abdomen can hardly be reached and the intra-abdominal room does not adequately unfold due to the weight of the abdominal wall.

Conclusion

Gasless laparoscopy using the AbdoLift abdominal wall retractor system combines the advantages of minimal invasive surgery with the advantages of the laparotomy, eliminating at the same time, the disadvantages of both methods.

The method thus fulfils the target criteria, as defined by Scheidel, for checking innovative treatment concepts. As patients experience less postoperative pain after the same operation, the therapy is more successful **(cost effectiveness).** Also a therapy result which is at least equally as good is achieved at a lower cost **(cost utility)** and the benefit of the therapy for the patient is increased, as both the costs and the complications are reduced **(cost benefit).**

References

1. Chernlack N S, Longobardo G S, Staw I, Heymann M: Dynamics of carbon dioxide stores changes following an alteration in ventilation. J Appl Physiol 21 (1966) 785-793
2. Alexander G D, Brown E M: Physiological alterations during pelvic laparoscopy. Am J Obstet Gynecol 105 (1969) 1078-1081.
3. Wolfe BM, Gardiner BN, Leary BF, Frey CF: Endoscopic cholecystectomy: an analysis of complications. Arch Surg 126 (1991) 1192 -1195.
4. Taura P. Lopez A, Lacy AM, Anglada T, Beltran J. Fernandez-Cruz L., Targarona E., garcia-Valdecasa JC, Marin JL: Prolonged pneumoperitoneum at 15 mm HG causes lactic acidosis. Surg Endose 12 (1998) 198-201.
5. Wittgen CM, Andrus CH, Fitzgerald SD, Baudenstel LJ, Dahms R, Kaminski DL: Analysis of hemodynamic and ventilatory effects of laparoscopic cholecystectomy. Arch Surg 126 (1991) 97-101.
6. McLaughlin JG, Bonnel BW, Scheeres DE, Dean RJ: The adverse hemodynamic effects related to laparoscopic cholecystectomy. Anestesiology 77 (1992) 70-77.
7. Brown DR, Fishburne JI, Roberson VO, Hulka JF: Ventilatory and blood gas changes during laparoscopy with local anesthesia . AM J Obstet Gynecol 124 (1976) 741-745.
8. ben-David B, Croitoru M, Gaitinin L: Acute renal failure following laparoscopic cholecystectomy: a case report. J Clin Anesth 11 (1999) 486-489.
9. Sharma KC, Kabinoff G, Ducheine Y, Tierney J, Brandstetter RD: Laparoscopic surgery and its potential for medical complications. Heart Lung 26 (1997) 52-64; quiz 65-67.
10. Koivusalo AM, Kellokumpu I, Ristkari S, Lindgren L: Splanchnic and renal deterioration during and after laparoscopic cholecystectomy: a comparison of the carbon dioxide pneumoperitoneum and the abdominal wall lift method. Anaest. Analg 85 (4) (1997) 886-891.
11. Naude GP, Ryan MK, Planim NA, Klein SR, Lippmann M, Bongard FS: Comparative stress hormone changes during helium versus carbon dioxide laparoscopic cholecystectomy. J Laparoendosc Surg 6 (1996) 93-98.
12. Montorsi M, Bona S, Rosati R, Fumagalli U: Le complicanze Intraoperatorie della colecistectomia laparoscopica: prevenzione e trattamento. Ann Ital Chir 62 (1991) 327-330.
13. Whiston J, Eggers KA, Morris RW, Stamatakis JD: Tension pneumothorax during laparoscopic cholecystectomy. Br J Surg 7 (1991) 1325-1328.
14. Ott DE: Contamination via gynaecologic endoscopy insufflation J Gynecol Surg 5 (1989) 205-208.
15. Volz J, Köster S, Weiss M, Schmidt R, Urbaschek R, Melchert F, Albrecht M: Pathophysiologic features of a pneumoperitoneum at laparoscopy: a swine model. Am J Obstet Gynecol 174 (1996) 132-140.
16. Johnson PL, Sibert KS: Laparoscopy, Gasless vs. CO_2 pneumoperitoneum. J Reprod Med 42 (1997) 255-259.
17. Goldberg JM, Maurer WG: A randomized comparison of gasless laparoscopy and CO_2 pneumoperitoneum.. Obstet Gynecol 90 (1997) 416-420.
18. Korelli M: Postoperative pain intensity after laparoscopy in general Surgery and Gynecology. Georg Thieme, Stuttgart - New York 1996, 34-38.

19. Guido RS, Brooks K, McKenzie R, Gruss J, Krohn MA: A randomized, prospective comparison of pain after gasless laparoscopy and traditional laparoscopy. J Am Assoc Gynecol Laparosc 5 (1998) 149-153.
20. Chiu AW, Chang IS, Birkett DH, Babayan RK: Changes in urinary output and electrolytes during gaseous and gasless laparoscopy. Urol Res 24 (1996) 361-366.
21. Woolley DS, Puglisi RN, Bilgrami SB, Quinn JV, Dlotman GJ: Comparison of the hemodynamic effects of gasless abdominal distension and CO_2 pneumoperitoneum during incremental positive end-expiratory pressure. J Surg Res 58 (1995) 75-80
22. Paolucci V, Scheff B (eds): Gasless laparoscopy in general surgery and gynecology, Georg Thieme, Stuttgart - New York 1996
23. Paolucci V, Scheff B, Gutt CN: Gasless laparoscopy - why and now? Min Invas Ther 4 (1995) 165-172.
24. Kruczynski D, Schäffer U, Knapstein PG: Gasless laparoscopy with conventional surgical instruments. Gynaecol Endosc 5 (1996) 277-281.
25. Kruczynski D, Bahlmann F, Schäffer U, Knapstein PG: “Laparoskotomie” - Die gaslose Laparoskopie mit konventionellen Instrumenten am Beispiel der Hysterektomie. Frauenarzt 36 (1995) 220-224.
26. Paolucci V, Scheff B, Gutt CN, Encke A: The gasless laparoscopic cholecystectomy. End Surg 3 (1995) 76-80
27. Paolucci V, Scheff B, Gutt CN, Encke A: Gasless laparoscopy in abdominal surgery. Surg Endosc 9 (1999) 497-500.
28. Kitano S, Iso Y, Tomikawa M, Oriyama M, Sugimachi K: A prospective randomised trial comparing pneumoperitoneum and U-shaped retractor elevation for laparoscopic cholecystectomy. Surg Endosc 7 (1993) 311-314).
29. Hill DJ, Maher PJ, Wood EC: Gasless laparoscopy - useless or useful? J Am Assoc Gynecol Laparosc (1994) 265-268.
30. Maher P, Hill D, Wood Cl: Laparovaginal hysterectomy - a new approach. Gynaecological Endoscopy 3 (1994) 129-1 32
31. Woodland MB: Ureterit injuries during laparoscopically assisted vaginal hysterectomy with endoscopic linear staples. Am J Obstet Gynecol 167 (1992) 756-757.
32. Friedmann W, Maier RF, Luttkus A, Schafer AP, Dudenhausen JW,: Uterine rupture after laparoscopic myomectomy. Acta Obstet Gynecol Scand 75 (1996) 683-684.
33. Dubuisson JB, Chavet X, Chapron C, Gregorakis SS, Morice P: Uterine rupture during pregnancy after laparoscopic myomectomy. Hum Reprod 10 (1995) 1475-1477.
34. Harris WJ: Uterine dehiscence following laparoscopic myomectomy. Obstet Gynecol 80 (1992) 545-546.
35. Pelosi MA 3rd, Pelosi MA: Spontaneous uterine rupture at thirty-three weeks subsequent to previous superficial laparoscopic myomectomy. Am J Obstet Gynecol 177 (1997) 15471549
36. Wu MP, Chen HH, Yen EYT, Tsai SC, Mo LR: A potential complication of laparoscopy - the surgeon´s herniated cervical disk. J Am. Assoc. Gynecol Laparosc 6 (1999) 509-511.
37. MacFadyen BV, Lenz S: The economic consideration in laparoscopic surgery. Surg. Endosc 8 (1994) 748-752.
38. Hidlebaugh D, O´Mara P, Conboy E: Salpingo-Oophorectomy: Clinical and financial analyses of laparoscopic and open techniques. J Am Assoc. Gynecol Laparosc 1 (1994) 223-227.
39. Kim EK: Current status of product for endoscopic surgery in Korea. Yonsei Med J 40 (1999) 554-558.

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