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REVIEW ARTICLE

Pain after laparoscopic surgery: Focus on shoulder-tip pain after gynecological laparoscopic surgery

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Abstract: Laparoscopy, one of minimally invasive procedures, is a commonly used procedure in diagnosis and management of various kinds of clinical problems, including gynecologic organ-related diseases. Compared with conventional exploratory laparotomy, the benefits of laparoscopic surgery include reduction of surgical wound, decreasing in postoperative pain, shortening hospital stay, rapid recovery, and a better cosmetic result. However, there are still up to 80% of patients after laparoscopic surgery complaining of high levels of pain and needing pain relief. Postlaparoscopic pain can be separated into distinct causes, such as surgical trauma- or incision wound-associated inflammatory change, and pneumoperitoneum (carbon dioxide [CO_2])-related morphological and biochemical changes of peritoneum and diaphragm. The latter is secondary to irritation, stretching, and foreign body stimulation, leading to phrenic neuropraxia and subsequent shoulder-tip pain (STP). STP is the most typical unpleasant experience of patients after laparoscopic surgery. There are at least 11 strategies available to attempt to decrease postlaparoscopic STP, including (1) the use of an alternative insufflating gas in place of CO_2, (2) the use of low-pressure pneumoperitoneum in place of standard-pressure pneumoperitoneum, (3) the use of warmed or warmed and humidified CO_2, (4) gasless laparoscopy, (5) subdiaphragmatic intraperitoneal anesthesia, (6) local intraperitoneal anesthesia, (7) actively expelling out of gas, (8) intraperitoneal drainage, (9) fluid instillation, (10) pulmonary recruitment maneuvers, and (11) others and combination. The present article is limited in discussing postlaparoscopic STP. We extensively review published articles to provide a better strategy to reduce postlaparoscopic STP.

Keywords: Pain; Postlaparoscopic surgery; Prevention; Reduction; Shoulder-tip pain

1. INTRODUCTION

The evolution of minimally invasive techniques for surgical intervention, including the purpose of diagnosis and therapy has resulted in the dramatic and significant change of the use of surgery in management of various kinds of diseases.[1–11] Minimally invasive surgery (MIS), including laparoscopic surgery, has been widely accepted in place of conventional exploratory laparotomy in management of various kinds of benign gynecologic diseases.[12–15] Among these, MIS is reported the best choice in the specific-type diseases, such as endometriosis.[16–20] MIS is as effective as conventional laparotomy for the management of certain-type gynecological malignancies, because of sharing similar advantages of MIS for benign gynecologic diseases but absence in deteriorated oncologic outcome.[21–26] Some recent reports have much concerned about the issue of safety in the use of MIS for cervical cancers.[27–30] We still believe that much effort has been developed to overcome the potential limitations of MIS with enthusiasm. MIS has many advantages, such as significant reduction in surgical incision wound, less wound-related pain, less analgesia use, minimally trauma and injury, better cosmetic results, a shorter hospital stay, rapid recovery time, and earlier return to daily activities and work compared with conventional exploratory laparotomy.[12–15,21–26]

Despite these advantages of MIS, there are still up to 80% of patients (ranging from 35% to 80%) who experience severe pain and require pain relief for their unpleasant feeling or suffering.[1,31–69] The characteristics of pain are different between MIS, especially gas laparoscopic surgery (keyhole surgery), and exploratory laparotomy. Shoulder-tip pain (STP) and upper abdomen pain are the best examples.[57–63] Early discharge and shorter hospital stay is popular in patients undergoing MIS; however, contributing to the high possibility of unfamiliarity to the post-MIS pain by both physicians and patients, it results in

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missing the diagnosis, and subsequently inadequate evaluation and improper management. Some are intolerable post-MIS pain, leading to a significant unnecessary increase of analgesia use, slower recovery, longer hospital stays, and rarely, readmission.[32]

A better understanding of the mechanism and/or pathophysiology of post-MIS pain can be presumed and developed from the increased number of clinical trials and a better strategy algorithm to maintain a regulated and orchestrated prevention and management.[31–69] The present article is a discussion of post-MIS pain, which limited to postoperative STP. We extensively review published articles to provide a better strategy to reduce postoperative STP.

2. PAIN

As shown above,[24–26,53,59,60] MIS is generally considered to be less painful than exploratory laparotomy. However, post-MIS pain still affects the quality of life and is one of the important reasons for delayed discharge or interference of coming back to normal activities.[55] Post-MIS pain can be separated into incisional pain, STP, and/or upper abdominal pain.

Pain is a sensory dimension (intensity) and an emotional dimension experience (unpleasantness) associated with actual or potential tissue damage.[70–72] Acute pain is the normal predicted physiological response to an adverse chemical, thermal, or mechanical stimulus, resulting from activation of the pain receptors (nociceptors) at the site of damage, which plays a critical and vital role in providing warning signals to avoid further damage and possibly be rescued from the damage.[70] Acute pain is also accompanied with the activation of sympathetic system of the autonomic nervous system which is reflective by tachycardia, diaphoresis, shallow and rapid respiratory pattern, restlessness, irritability, facial grimacing, anxiety, pallor, pupil dilation, and/or hypertension.[70] Since MIS-related (laparoscopic gynecological surgery-related) pain involves skin, peritoneal and visceral organs, the pain can be originated from nociceptive pain or non-nociceptive pain. The former includes somatic pain (well localized typographically) and visceral pain (diffuse and poorly localized, referable, accompanied with motor and autonomic reflexes, such as nausea and vomiting), and the later includes neuropathic or idiopathic pain.[70]

Nociceptive pain is an initiation of releasing and producing numerous factors, such as globulin, protein kinases, arachidonic acid, histamine, nerve growth factor, substance P, calcitonin gene-related peptide, among others, and stimulates transducer channels by damaged tissue, and then activates or sensitizes nociceptors in the periphery, followed by transducing noxious stimulus into electrochemical impulse and transmitting to the dorsal horn of the spinal cord and crossing over to the contralateral side to the higher rostral centers in the central nervous system (thalamus or other brain areas like dorsolateral pons).[70–72] Acute and well-localized fast pain is mediated through medium diameter myelinated afferents, including A-delta, also calling type I with characteristics of higher temperature thresholds but low threshold to mechanical and chemical stimuli and type II characterized with a much greater sensitivity to heat but a very high mechanical threshold.[72] By contrast, a poorly localized and slow pain is mediated by small diameter unmyelinated fibers (polymodal fibers responding to both mechanical and thermal noxious stimuli).[72]

3. INCISIONAL WOUND PAIN

Incisional wounds, ranging from one incision (single port wound) to multiple and separate incisions (multiple port wounds) need a cut in the skin, subcutaneous tissues, and peritoneal tissues.[11] It causes damage of the tissues (producing wounds), subsequently resulting in the stimulation of peripheral nociceptors to produce pain sensation.[70–72] In addition, inflammation of the wound can stimulate the nociceptors with resultant and exacerbating pain.[73–77] Therefore, aspirin, and selective and nonselective nonsteroidal anti-inflammatory drugs, having been known as analgesic, antipyretic and anti-inflammatory effects, are reported to inhibit prostaglandin E2 production and act as effective painkillers.[78–83] In addition, some opioid types analgesia or central types of pain-relieving agents, such as paracetamol, or steroid drugs are also frequently used in patients after surgery.[77,84–87] The above-mentioned medication can be provided by oral, intravenous, or intramuscular routes; however, only oral form can be taken after discharge. Although oral medication is convenient,[88] gastrointestinal tract irritation and possible side effects, such as allergy may occur.[89–95] Therefore, immediate and adequate pain control to minimize the pain scores (visual analog scale [VAS] ranging from 0 to 10 cm) and no need of further care after discharge is welcomed.[96–100] Therefore, wound infiltration with local anesthetic agents done at the end of the surgery is tested. One meta-analysis study showed the effectiveness of the use of local anesthesia infiltration to the incisional wound in the reduction of wound pain after laparoscopic surgery.[56] The pain scores were statistically significantly lower in the incisional wound by local anesthetic infiltration than no local anesthesia group at 4 to 8 hours (13 trials containing 806 subjects with mean difference [MD] -1.33 cm on the VAS; 95% CI, -1.54 to -1.12) and 9 to 24 hours (12 trials containing 756 subjects; MD -0.36 cm on the VAS; 95% CI, -0.53 to -0.20), respectively, contributing to higher proportion of patients who were discharged as day surgery (66% vs 42.6%).[56] However, the length of hospital stay was not different between the local anesthetic agent treatment group and the control group,[56] supporting the concept that significantly less wound pain occurs in patients undergoing MIS and wound pain after MIS is not a remarkable issue for both physicians and patients. Therefore, the clinical importance of this reduction in pain (incisional wound pain after laparoscopic surgery) is likely to be small.[56]

4. CAUSES OF STP

The cause of post-MIS STP is not fully elucidated, and supposed multifactorial and possibly referred pain.[1] Probable explained theories are least three. The first theory is carbonic acid production inducing a reduction in the peritoneal pH to damage and irritate the peritoneal and diaphragmatic nerves, leading to STP.[32,60] This irritative effect of carbonic acid on the peritoneum and diaphragm is due to the conversion of carbon dioxide (CO_2) gas to carbonic acid by carbonic anhydrase,[101–103] which occurs in the moist surface of peritoneum and diaphragm.[60] The further evidence is supported by the use of carbonic anhydrate inhibitor-acetazolamide in the reduction of STP dramatically,[104] although the similar results cannot always be reproduced by other studies.[32,66,105]

The second theory is the residual pockets of gas in the abdominal cavity (also calling visceral ligament traction), which is supported by the followings: (1) presence of CO_2 gas pockets between the liver and diaphragm leading to loss of negative pressure in the peritoneal cavity, and thereby the loss of suction support of the liver and diaphragm, allowing traction on the triangular and coronary ligaments of the liver, leading to subdiaphragmatic pain and STP; (2) a close correlation between the amount of residual gas or CO_2 bubble volume under the right hemidiaphragm and STP; (3) the positive correlation between delayed absorption of CO_2 and longer STP; (4) the positional nature of STP occurring when women are sitting up and mobilizing; and (5) the STP occurring generally more than four hours after procedure.[60]

The last is the tissue trauma theory (also calling neuropraxia theory). The stretching and/or injury of the peritoneum and diaphragm by pneumoperitoneum results in tearing of blood vessels, traction of nerves (eg, phrenic nerve), and release of inflammatory mediators, which elicit the referred pain to the shoulder.[60] The correlation of the degree of stretching and the severity of STP has been reported before.[106]

After discussing the possible causes of postlaparoscopic STP, the next section focuses on the strategy in the prevention and reduction of severity of STP. The strategies include the use of an alternative insufflating gas in establishing pneumoperitoneum; the use of warmed or humidified insufflating gas, low-pressure pneumoperitoneum; intraperitoneal fluid instillation; the use of intraperitoneal anesthetic agents; the use of intraperitoneal drains; and specific methods for expelling out of gas, such as active suction of gas or manually forcing gas out of the abdominal cavity at the end of surgery and pulmonary recruitment maneuver (PRM).[31–69]

5. THE USE OF AN ALTERNATIVE INSUFFLATING GAS IN THE REDUCTION OF STP

To perform the laparoscopic surgery, the establishment of pneumoperitoneum is a crucial element. It is an initial step to provide sufficient working and viewing space and ensure adequate visualization of camera and manipulation of instruments when laparoscopic surgery is performed.[40] To establish pneumoperitoneum, two steps are needed, including the initial set up of port wound (entry into the abdominal cavity via trocar) and the following insufflation of gas and of course, reverse of them (insufflation of gas initially via Veress needle and the following trocar insertion) is also used in routinely clinical practice.[40]

The ideal gas to establish pneumoperitoneum should fulfill the following criteria, including cheap, easy to obtain, colorless, nonflammable, nonexplosive, easily excreted, and completely nontoxic to patients.[40] There are many gases available to act the resource for establishing pneumoperitoneum. They are CO_2, helium, argon, nitrogen, nitrous oxide, room air, and others.[40] Carbon dioxide is the most popular and well-known gas for this purpose, although CO_2 is still not an ideal form. There are many concerns about the use of CO_2 for laparoscopic surgery because CO_2 is soluble and can be absorbed by the peritoneum and delivered directly to the lung by circulation, which may induce metabolic and respiratory changes.[40] This acid-based balance might be destroyed during laparoscopic surgery with CO_2. Therefore, the risk of hypercapnia, acidosis, and cardiopulmonary complications, such as tachycardia, cardiac arrhythmia, and lung edema may be increased.[40] In addition, this metabolic and respiratory imbalance might destroy the normal immune response of the host. Finally, as shown above, CO_2 is a potential cause of postlaparoscopic STP. All of these might be more apparent in the elderly population.[40] During laparoscopy, monitoring of end-tidal CO_2 concentration is mandatory.

However, the risk of venous or arterial air embolization might be lower in laparoscopic surgery with CO_2, based on the characteristics of CO_2 with easy solubility and quick absorption. In contrast, other gases, such as helium, argon, nitrogen, nitrous oxide, and room air, are not so soluble as CO_2 and need much more time to be absorbed. At the end of surgery, special attention should be done when pneumoperitoneum is established. In addition, it is necessary to maintain low intra-abdominal gas pressure during operation and try much effort to expel the gas out of the abdominal cavity at the end of surgery when these relatively insoluble gases are used. All will increase the risk of air embolization during operation or after operation. That is why there are many studies trying to evaluate the feasibility and safety of the using alternative gases in place of CO_2 for laparoscopic surgery. Unfortunately, results are not consistent.[40,107–112] Of most importance, safety issue of these alternative gases is always concerned.[40,107–112]

6. THE USE OF LOW-PRESSURE PNEUMOPERITONEUM IN THE REDUCTION OF STP

As shown before, to permit organs and structures within the abdominal cavity to be viewed, inflation of the abdominal cavity with CO_2 (pneumoperitoneum) should be given during laparoscopic surgery.[60] Pneumoperitoneum (with increasing intra-abdominal pressure) significantly decreases venous return, preload, and cardiac output, as well as increases heart rate, systemic and pulmonary vascular resistance, resulting in the stimulation of neurohumoral vasoactive system, regardless of which type of gas is given.[113]

The gas pressure for gynecologic laparoscopic surgery usually ranges from 12 mmHg to 14 mmHg (no exceeding 15 mmHg) because the study showed that in ASA (the American Society of Anesthesiologists classification) I and II patients, the hemodynamic and circulatory effects of these pressures are generally not clinically relevant.[113] However, this pressure is one of causes contributing to the unwanted side effects, such as STP, and sometimes, this standard pressure might increase the risk of intraoperative hemodynamic instability in ASA III and IV patients.[113] Therefore, if technically feasible, gasless or low-pressure pneumoperitoneum should be considered for patients with limited cardiac and pulmonary function, contributing to the consideration of using low-pressure in place of the standard-pressure to establish pneumoperitoneum during laparoscopic surgery.[60,113]

As expected, low pressure results in inadequate pneumoperitoneum, and inadequate operative field, contributing to impairment of identification of normal organs and target lesions, and of most importance, low pressure may be correlated with technique difficulty and subsequently increasing risk of intraoperative complication and possible life-threatened situation. Previous trial has shown that pain can be successful reduced by low-pressure pneumoperitoneum but operative time is longer, and hemorrhage is also increased compared with standard-pressure and high-pressure pneumoperitoneum,[57] supporting uncertainty of safety of low pressure pneumoperitoneum when we perform laparoscopic surgery.

In 2014, a Cochrane review found that approximately 90% of people could be successfully managed by low-pressure laparoscopic cholecystectomy, but the authors concluded no evidence to support the use of low-pressure pneumoperitoneum in routine and uncertainty of safety of low-pressure pneumoperitoneum.[60] In 2015 and 2016, review also found that low pressures were associated with worse visualization of the surgical field (risk ratio, 10.31; 95% CI, 1.29-82.38), although a statistically significant but modest diminution in postoperative pain of MD, -0.38 cm on the VAS (95% CI, -0.67 to -0.08) during the immediate postoperative period when using low pressure of 8 mmHg compared with ≥ 12 mmHg and of MD, 0.50 cm on the VAS (95% CI, -0.80 to -0.21) 24 hours after the laparoscopic surgery.[114,115] Therefore, the authors did not suggest the use of low pressure during gynecologic laparoscopy because of minimal improvement of pain scores but significantly compromising visualization of the surgical field.[114,115]

Two recent prospective randomized trials tried to evaluate the feasibility of the use of low-pressure laparoscopic surgery in the management of benign gynecologic pathology.[1,46] Low-pressure was set up as 7~8 mmHg, and standard-pressure was 15 mmHg CO_2. The results of both studies showed patients undergoing low-pressure laparoscopic surgery had significantly lower postlaparoscopic abdominal pain and STP scores.[1,46] In addition, fewer vegetative alterations, lower pain medication requirements, a shorter postoperative hospital stay, and lower intra- and postoperative arterial partial pressure of carbon dioxide values are found in the women undergoing low pressure laparoscopic surgery compared to those undergoing the standard-pressure laparoscopic surgery,[1] suggesting low-pressure laparoscopic surgery for benign lesions is a feasible and safe technique.[1,46]

7. GASLESS LAPAROSCOPY AND ACTIVELY EXPELLING OUT OF GAS TO REDUCE STP

It is interesting to find studies to use different strategies to decrease residual gas within the abdominal cavity at the end of laparoscopic surgery.[49,116,117] One is an earlier prospective randomized trial in 1998 to show there is no statistical difference in scores for STP between gasless (a Laprolift system) and standard-pressure laparoscopic surgery for tubal ligation.[116] The other study found that the active gas aspiration has lowered pain intensity of STP scores than the simple gas evacuation does, and these statistically significant results are found at 6, 12, and 24 hours after surgery, suggesting active gas aspiration is recommended in routine for decreasing postoperative STP.[49] To remove residual air within the abdominal cavity as much as possible, the air can be first vacuumed from the pelvic cavity in Trendelenburg position and then the patients are put in anti-Trendelenburg position, where the remaining gas can be shifting toward subdiaphragmatic area, and the suction tube is shifted to a position next to the camera canal and the remaining air is suctioned.[117] Although the results are not consistent, we still favor the effort to remove the gas in the abdominal cavity as much as possible to minimalize the residual volume of gas at the end of laparoscopic surgery.

8. THE USE OF WARMED OR WARMED AND HUMIDIFIED CO_2 IN THE REDUCTION OF STP

Carbon dioxide used in laparoscopic surgery is typical at 21°C with 0 percent relative humidity.[117] This cold and dry gas may cause hypothermia, and postoperative pain or fatigue.[117] Therefore, it is rationale to suppose that the use of warmed and humidified gas in place of cold and dry gas might decrease the postlaparoscopic STP. In fact, this hypothesis was supported by the earlier meta-analysis.[118] A statistically significant reduction of pain (MD, -0.39 cm on the VAS, 95% CI, -0.67 to -0.18 within 6 hours, MD, -0.34 cm on the VAS, 95% CI, -0.61 to -0.07 on day 1, and MD, -0.88 cm on the VAS, 95% CI, -1.30 to -0.45 on day 3, respectively) was found in the humidification and warming of the insufflated CO_2 group compared to conventional insufflation of cold and dry CO_2 group.[118] The study further supported the benefits of the use of heated humidified CO_2 in place of dry and cold CO_2 for laparoscopic surgery, because the former is associated with lesser postoperative pain, lower risk of postoperative hypothermia, and lower analgesic requirements.[119] It is reasonable to use warmed and humidified CO_2 for laparoscopic surgery, but this suggestion is still not popular in routinely clinical practice. In fact, a recent meta-analysis focusing on gynecologic laparoscopy, including three studies[120–122] to assess severity of STP and postoperative analgesia usage found there was no evidence of a difference in the incidence, severity or analgesia requirements between women treated with warming, or warmed and humidified insufflation gas and gas in routine use.[32] We favor the use of warmed and humidified insufflation gas for laparoscopic surgery if applicable, but the benefit/cost ratio is still uncertain.

9. THE USE OF SUBDIAPHRAGMATIC INTRAPERITONEAL ANESTHESIA OR LOCAL INTRAPERITONEAL ANESTHESIA IN THE REDUCTION OF STP

As shown before, pain secondary to laparoscopic surgery has been attributed to stretching of the intra-abdominal cavity, peritoneal inflammation, and establishment of pneumoperitoneum and dissection of the abdominal and pelvic viscera.[32,123] Local administration of anesthesia might have lowered risk of sedation, nausea, gastrointestinal irritation or injury, as well as paralysis, respiratory depression, and allergic effects than systematic use of analgesia has.[123,124]

Intraperitoneal analgesia after laparoscopic surgery might directly acts at the site by causing a reversible interruption of nervous conduction, and subsequent inhibiting the visceral afferent signaling. Meta-analysis showed that patients treated with intraperitoneal local anesthesia may have a statistically significant reduction of pain scores within the first 6 hours after laparoscopic surgery (MD, -1.82 cm on the VAS, 95% CI, -2.55 to -1.08 at 1 to 2 hours, and MD, -2.00 cm on the VAS, 95% CI, -3.64 to -0.35 at 4 to 6 hours postoperatively, respectively).[123] However, this effect was not statistically significant difference at 24 hours postoperatively.[123] A meta-analysis published in 2019, including many trials,[125–127] also supported the evidence that intraperitoneal local anesthesia (not spreading to sub-diaphragm) can be associated with a statistically significant reduction of incidence of STP (odd ratio [OR], 0.23; 95% CI, 0.06-0.92).[32] Similar to the reduction of STP in the patients treated with intraperitoneal local anesthesia, patients treated with subdiaphragmatic intraperitoneal local anesthesia also had a statistically significant reduction of severity of STP at 8 hours postoperatively (MD, -0.95 cm on the VAS, 95% CI, -1.70 to -0.19).[32] However, it is interesting to find that pain reduction at the different postoperative time points to evaluate incidence or severity of STP seems to be varied greatly. The effectiveness seems to occur immediately after laparoscopic surgery and the effect of pain reduction disappears in the later. That is to say, the reduced pain scores occur transiently and cannot be maintained.

10. THE USE OF INTRAPERITONEAL DRAINAGE IN THE REDUCTION OF STP

Drains are commonly used after surgeries and can be classified as either active or passive by mechanisms and either informative (prophylactic) or therapeutic by purpose.[128–137] In addition, vacuum drains can further be classified as high negative pressure (typical bottled vacuum drains, such as Redi-vacTM drain (Redivac, Inc, Daventry, Northamptonshire, UK), with advantages of being sealed, closed-circuit system allowing for easy monitoring and safe disposal of the drainage) and low negative pressure, such as bulk-shaped suction devices (eg, Jackson-Pratt, compression of bulb to force air out to create negative pressure in the system) and collapsible four-channel vacuum drains J Vac (Blake drain, Ethicon, Inc, Somerville, NJ).[132] After laparoscopic surgery, a dead space and pneumoperitoneum is created, and body has a natural tendency to fill this space with fluid or air. Therefore, prophylactic low-negative-pressure drains can be used to work gently to evacuate excess fluid and air, although it is not routinely recommended. An earlier meta-analysis did not support the routine use of a peritoneal gas drain following gynecological laparoscopy because of very little evidence of an overall benefit from this approach, and in addition, no association with a reduction in the requirement of analgesia and anti-emetics for STP and total pain when compared to no use of peritoneal gas drain group.[135] A recent meta-analysis showed there is associated between an intraperitoneal drain and a reduction in the incidence of STP when compared with no intraperitoneal drain at all time points assessed postoperatively with OR, 0.47 (95% CI, 0.25-0.86) at 3-4 hours; OR, 0.08 (95% CI, 0.02-0.36) at 12 hours; OR, 0.3 (95% CI, 0.2-0.46) at 24 hours; and OR, 0.4 (95% CI, 0.21-0.74) at 48 hours postoperatively, respectively.[32] Not only is incidence of STP decreased when drain is applied after laparoscopic surgery, but also severity of STP decreased with MD, -1.69 cm on the VAS, 95% CI, -2.2 to -1.19 at 12 hours postoperatively; MD, -1.85 cm on the VAS, 95% CI, -2.15 to -1.55 at 24 hours after operation; MD, -0.7 cm on the VAS, 95% CI, -0.95 to -0.44 at 48 hours postoperatively; and MD, -0.8 cm on the VAS, 95% CI, -1.15 to -0.05 at 72 hours postoperatively, respectively.[32]

11. THE USE OF PRM IN THE REDUCTION OF STP

Since CO_2 or gas pneumoperitoneum is one of most common causes inducing postoperative STP, specific technique for releasing the pneumoperitoneum (expelling out of gas as much as possible to minimize the residual gas within the abdominal cavity after laparoscopic surgery) may be effective in reducing postoperative STP. PRM involve positive pressure ventilation (40~60 cm H_2O for five breaths with the final inflation breath being held for a maximum of 5 seconds) with combination of gentle abdominal pressure at the completion of the laparoscopic surgery whilst the patients are still in a Trendelenburg position to expel CO_2 out via open trocars in the abdominal wall.[32,61,64] Since PRM seems to be an easily performed and potentially preventive strategy of postoperative STP, many physicians highly recommended its routine use. In fact, an earlier meta-analysis also supported the benefits of the use of PRM in the reduction of postoperative STP at the end of laparoscopic surgery, because PRM significantly decreased postoperative STP 12 hours (MD, -1.55 cm on the VAS, 95% CI, -2.01 to -1.10), 24 hours (MD, -1.59 cm on the VAS, 95 % CI, -2.00 to -1.18), and 48 hours postoperatively (MD, -0.93 cm on the VAS, 95 % CI, -1.37 to -0.50), respectively.[50] A recent meta-analysis failed to show the reduction of incidence of postoperative STP in patients treated with PRM (OR, 0.77; 95% CI, 0.57-1.05 and OR, 0.79; 95% CI, 0.56-1.11) compared to those treated with standard control.[32] However, in agreement with an earlier meta-analysis to have a reduction of severity of STP in PRM group,[50] a statistically significant reduction of STP is found at all times investigated, including MD, -0.29 cm on the VAS, 95 % CI, -0.48 to -0.09 at 3-6 hours; MD, -0.58 cm on the VAS, 95% CI, -0.78 to -0.37 at 12 hours; MD, -0.66 cm on the VAS, 95 % CI, -0.82 to -0.50 at 24 hours; MD, -1.26 cm on the VAS, 95% CI, -2.23 to -0.29 at 36 hours; and MD, -0.72 cm on the VAS, 95 % CI, -0.99 to -0.45 at 48 hours after laparoscopic surgery, respectively.[32]

12. THE USE OF FLUID INSTILLATION IN THE REDUCTION OF STP

Intraperitoneal fluid instillation with 1000~1500 mL of warm saline (or 15~30 mL/kg body weight) into the abdominal cavity was performed in patients at the end of the gynecological laparoscopic procedures whilst patients are still in Trendelenburg positioning until it "spilled out of the remaining open trocars".[32,61,64] Meta-analysis seems to support the value of fluid instillation in the reduction of STP, because of lower incidence of STP in the fluid instillation group with OR, 0.67; 95% CI, 0.39-1.14 at 12 hours; OR, 0.38; 95% CI, 0.22-0.66; and OR, 0.38; 95% CI, 0.21-0.67, respectively; and less severity of STP in the fluid instillation group with MD, -1.69 cm on the VAS, 95% CI, -2.55 to -0.83 at 12 hours; MD, -2.27 cm on the VAS, 95% CI, -3.06 to -1.48 at 24 hours; and MD, -1.44 cm on the VAS, 95% CI, -2.07 to -0.81 at 48 hours postoperatively, respectively compared to no fluid instillation group.[32,61,64]

13. THE USE OF COMBINATION METHODS IN THE REDUCTION OF STP

As shown comments by Dr. Sharp HT[62] for our previous publication,[61] most of us have tried some methods to reduce one clinical problem, but there are some patients still suffering from other clinical problems. STP and surgical pain might be different, and many clinical problems might be complicated and multifactorial. Therefore, combination of many methods to become a brand new strategy might be a better choice, which may cover more clinical situations. In fact, recent prospective randomized studies seem to be conducted as the use of different combination of all effective tools in the management of troublesome clinical problems. Our previous study using the combination of PRM and NS instillation can successfully and effectively decrease upper abdominal pain and STP,[61] although the recent study by van Dijk et al[34] cannot reproduce our findings. However, in the study by van Dijk et al[34], the mean VAS score for abdominal pain at 8 hours after surgery was indeed significantly lower in the intervention group compared with the control group (3.2 vs 4.2; p = 0.02),[34] suggesting feasibility and acceptability of this approach for the patients who undergo laparoscopic gynecologic surgery.

In conclusion, MIS is popular and well-come procedures, which can be used as better alternatives in the management of various kinds of gynecological diseases or other surgical interventions. To achieve the better road to take care of the patients who need surgical intervention, any improvement of quality of life after operation should be taken into consideration. Pain is the fifth vital sign, emphasizing the need to reduce patient suffering.[62] Safety is a priority for all managements, therapies, and surgeries. Any inexpensive low-technology method, eg, instillation of normal saline at the conclusion of laparoscopic gynecologic procedures to reduce postoperative STP is welcome. We should always be cautious about the fluid overload for patients who are risky in cardiovascular diseases. In fact, instillation of normal saline within the abdominal cavity, this approach has been used very commonly for adhesion prevention at the end of surgery.[62] Based on the current review, a specific technique for releasing the pneumoperitoneum; intraperitoneal fluid instillation; an intraperitoneal drain; and local anesthetic applied to the peritoneal cavity or to the subdiaphragmatic area, and warmed and humidified insufflating gas may play a role on the reduction of postoperative STP, although evidence needs more studies to verify.

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