Gynecol Surg (2013) 10:169–175
DOI 10.1007/s10397-013-0791-7

REVIEW ARTICLE

Techniques to reduce shoulder pain after laparoscopic surgery for benign gynaecological disease: a systematic review

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Received: 19 February 2013 / Accepted: 28 March 2013 / Published online: 27 April 2013

Abstract Due to the well-known advantages of minimal invasive surgery, the majority of procedures for benign gynaecological diseases are performed by laparoscopy. Although laparoscopic surgery results in improved patient satisfaction, a considerable portion of patients have complaints of post-operative shoulder pain. This review presents an overview of the currently evaluated techniques to reduce shoulder pain after laparoscopic surgery for benign gynaecological disease. According to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines, a systematic review was conducted using Medline, Embase and Cochrane databases. Randomised clinical trials reporting techniques to reduce shoulder pain after laparoscopic gynaecologic procedures for benign diseases were included. Eighty-eight articles were screened for inclusion. A total of 15 articles were included in the final review. The following studies described the techniques used to reduce shoulder pain: six studies evaluated the effect of local anaesthetics, three studies evaluated the effect of pulmonary recruitment manoeuvre and three studies evaluated the effect of intraperitoneal drainage. The remaining three studies evaluated the effect of saline installation, minilaparoscopy and gasless laparoscopy by using the Laprolift®. Overall, the pulmonary recruitment manoeuvre and intraperitoneal drainage were found to reduce the incidence and severity of shoulder pain (SP). Based on the current evidence, safety and possibility to implement the technique in daily practice, pulmonary recruitment manoeuvre can be recommended to reduce both the incidence and severity of SP.

Keywords Laparoscopy · Gynaecology · Shoulder pain · Gynaecologic surgery

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Introduction

Laparoscopic surgery in patients with benign gynaecological diseases has several advantages compared to open surgery such as faster recovery, reduced hospital stay, lower morbidity and better cosmetic results [1–4]. Although laparoscopic surgery results in improved patient satisfaction, a considerable portion of patients have complaints of post-operative shoulder pain (SP). Post-operative SP is hypothesised to be a result of pneumoperitoneum achieved by carbon dioxide insufflation which induces peritoneal stretching, irritation of the diaphragm and phrenic nerve resulting in referred pain to the shoulder [5]. The precise aetiology is not fully known.

The incidence of SP in the first post-operative day is 35 to 61 % [6–8]. The severity ranges from mild to severe, and some patients even have SP for more than 72 h after surgery [9]. While the exact pathogenesis of post-operative SP is not fully understood, different techniques to reduce the incidence and severity of SP after benign gynaecological laparoscopy have been evaluated in the literature.

The aim of this study was to critically appraise the effectiveness of different techniques in reducing post-operative SP after laparoscopic surgery in terms of the incidence and/or severity of SP. If enough high-quality studies were retrieved and if a clinically relevant and statistically significant difference was demonstrated, we aimed to give a recommendation for daily practice.

Methods

Search strategy

On the basis of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis, a systematic review was conducted. The literature search was conducted by a clinical librarian in the Medline, Embase and Cochrane databases. All randomised controlled trials (RCTs) published in the English language were selected for screening based on the following search terms: "shoulder pain" and "gynecologic" and "laparoscopy". No restriction in the year of publication was applied. The exact search terms are demonstrated in the appendix wherein a combination of MeSH terms and free text words was applied.

Study selection

Two independent reviewers selected all relevant articles. First, the authors eliminated independently and simultaneously all duplicates and articles that were not relevant by looking at the titles and/or abstracts. Subsequently, the relevant articles were selected on the basis of reading the full text manuscripts. The eligibility criteria for inclusion were based on study design and outcome measurements. The outcome measurements include incidence of shoulder pain, severity of shoulder pain on any scale and the need for post-operative analgesics. For study design, only RCTs reporting techniques to reduce SP after benign laparoscopic gynaecologic procedures under general anaesthesia were included. For outcome measurements, only studies reporting the incidence and/or the severity of "shoulder pain" or "shoulder tip pain" were included. The severity of shoulder pain could be assessed on any scale.

The two reviewers identified the articles that met the eligibility criteria. The final inclusion of articles was based on reading the full article. If disagreement regarding inclusion occurred, an agreement was reached by discussion. Finally, to identify other relevant RCTs, a manual search was made in the reference lists of the reviewed papers.

Data extraction

The following data were extracted from the included RCTs: year of publication, total number of participants and respective allocation, laparoscopic procedure, intervention type, administration method and location for intraperitoneal solutions, significant and non-significant results on incidence and/or severity of SP measured on any scales at rest/cough/mobilisation and post-operative analgesic consumption. The data extracted are presented in tables for each intervention type.

Results

The search strategy identified 88 articles which were screened for inclusion. Fifteen RCTs were included in the final review. Reasons for exclusion are presented in the flow chart (Fig. 1). Of the included RCTs, six studies evaluated the effect of intraperitoneal local anaesthetics [10–15], three studies evaluated the effect of pulmonary recruitment manoeuvre (PRM) [5, 8, 16] and three studies evaluated the effect of drainage [17–19]. The remaining three studies have been grouped together as "other techniques" and evaluated the effect of intraperitoneal saline installation [20], minilaparoscopy [21] and gasless laparoscopy by using Laprolift® [22]. One of the studies primarily evaluating PRM also had an intervention arm evaluating intraperitoneal saline vs. nothing [15]. The results from this arm have been included in "other techniques".

Due to the heterogeneity of the included studies, it was not possible to convert the outcome measurements into dichotomous data or continuous data in order to demonstrate an overall effect. Therefore, no estimates of treatment effects or meta-analyses are presented in this systematic review. Instead, we preferred to indicate if a significant effect was demonstrated ($p<0.05$). As it would have no direct consequences on the results presented here, we decided making an evaluation of risk of bias for the included studies.

Intraperitoneal local anaesthetics

Six RCTs evaluated the effect of intraperitoneal local anaesthetics [10–15]. The results are presented in Table 1. The administration method, location and type of intraperitoneal local anaesthetics varied between studies (Table 1). The severity of SP was assessed by using the visual analogue scale (VAS) in all studies [10–15]. One study assessed SP at rest using VAS and SP during coughing on a four-point scale [14]. Three studies reported VAS at rest and during coughing/mobilisation [11, 13, 14]. One study assessed VAS at rest [15]. The final two studies did not report the method of the VAS assessment [10, 12]. In one study, the control group received no intraperitoneal solution [13]. In the remaining five studies, the control group received saline solution [10–12, 14, 15]. None of the studies found a significant reduction in the incidence of SP [11–15]. Only two out of six studies found a significant reduction in SP severity [10, 14]. One of these only found a significant reduction of SP severity during coughing in the first post-operative hour [14]. All studies reported post-operative analgesic consumption. A significant decrease in analgesic requirement was found in three out of six studies [10, 11, 14].

Pulmonary recruitment manoeuvre

Three RCTs evaluated the effect of PRM [5, 8, 16]. The results are presented in Table 2. All studies reported both the

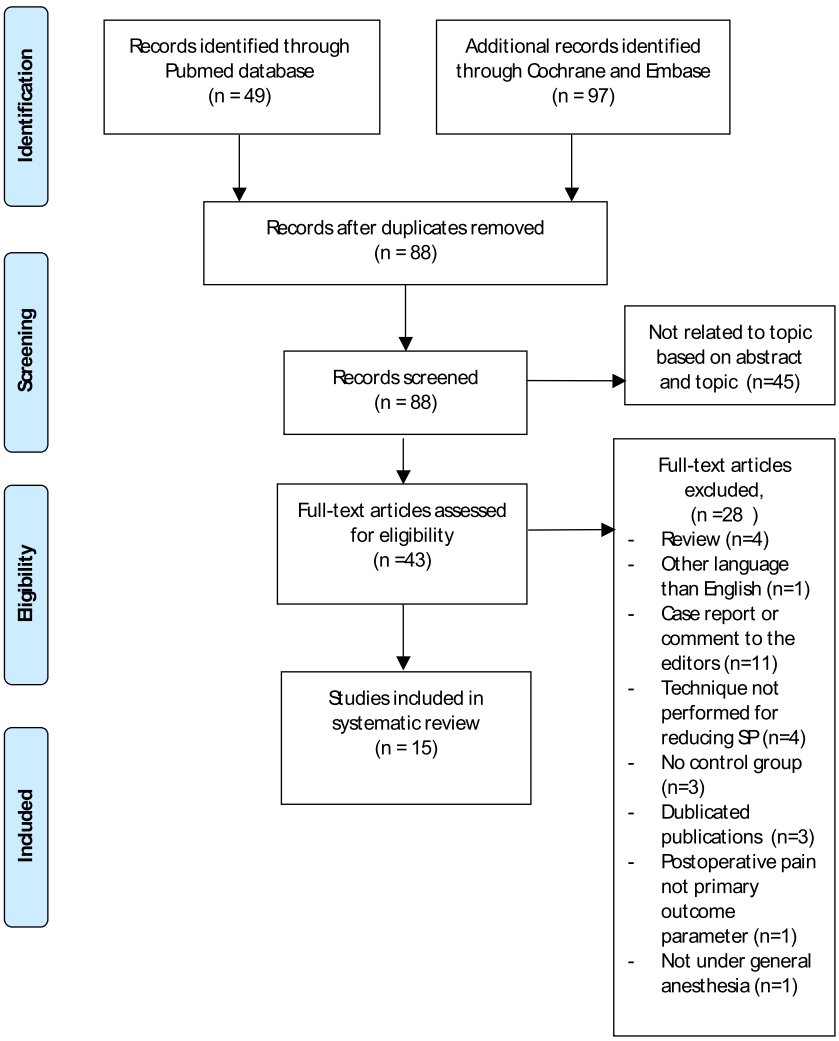

Fig. 1 Flow diagram demonstrating the selection process of included studies

incidence and severity of SP [5, 8, 16]. In all studies, post-operative SP was assessed using VAS and PRM resulted in a significant reduction in the incidence of SP [5, 8, 16]. Two studies also found a significant reduction in the severity of SP [8, 16]. Two studies measured the VAS scores at rest [8, 16], and the last study did not report whether they measured the VAS at rest or during cough/mobilisation [5]. The significant effect of PRM on SP severity was found 4–24 h after surgery and 12 h after discharge [16] and at 24 h post-operatively [8]..

Two out of three studies reported post-operative analgesic consumption [8, 16]. In one of these studies, a significant reduction in post-operative analgesic requirements was found [16].

Drainage

Three RCTs evaluated the effect of drainage [5, 8, 16]. The results are presented in Table 3. Two studies assessed the severity of SP by using VAS [17, 18], and one assessed the severity by a follow-up questionnaire [19]. One study measured the severity of SP both at rest and during coughing [19]. The last two studies did not report whether the measurement was done at rest and/or during coughing/mobilisation [17, 18]. One study reported both the incidence and severity of SP [18] and found a significant reduction in both (severity at 24 h and 48 h post-operatively) [18]. The last two studies reported only the severity of SP and found a significant reduction compared with the control group (12–72 h post-operatively [17] and at 4 and 48 h post-operatively [19]). Two studies reported post-operative analgesic consumption, and both found a significant reduction in the post-operative analgesic requirements [18, 19].

Other techniques

The remaining three RCTs investigated the effect of gasless laparoscopy using Laprolift® [22], minilaparoscopy [21] and intraperitoneal saline [8]. The results are presented in Table 4. None of the studies reported on SP incidence. All studies reported the severity of SP using VAS. The only intervention that reduced the severity of SP was intraperitoneal saline

Table 1 The effect of intraperitoneal local anaesthetics (LA) on the incidence and severity of shoulder pain (SP)

Reference	Publication year	Number	Procedure	Intervention	Control	Administration	Site	Incidence SP	Severity SP	Post-operative analgesics
Benhamou et al. [10]	1994	50, 25/25	Sterilisation	Lidocaine	Saline	Infusion	Right subdiaphragmatic area	N/A	↓	↓
Callesen et al. [11]	1999	80, 40/41	Sterilisation	Ropivacaine	Saline	Infusion	Pelvic cavity	–	–	↓
Johnson et al. [12]	1994	77, 39/38	Sterilisation, laparoscopy	Bupivacaine	Saline	Flushed	Abdominal cavity	N/A	–	–
Kaufman et al. [13]	2008	40, 20/20	Salpingo-oophorectomy, ovarian cystectomy	Ropivacaine	Nothing	Nebulization	Abdominal cavity	–	–	–
Ozer et al. [14]	2005	51, 26/25	Not specified	Bupivacaine	Saline	Subphrenic catheter	Right subdiaphragmatic area	–	↓	↓
Chou et al. [15]	2005	79, 26/27	Not specified	Bupivacaine	Saline	Infusion	Pelvis cavity, subdiaphragmatic area	–	–	–

N/A not available, ↓ significant decrease, – not significant

administration [17]. One of the studies evaluating PRM also evaluated intraperitoneal saline in a separate arm and found a significant reduction in both the incidence and severity of SP [8]. This reduction was also found when intraperitoneal saline was compared to PRM [8].

Discussion

In this systematic review, PRM showed overall promising results in reducing both the incidence and severity of SP after laparoscopic surgery for benign gynaecological disease. Despite this, only one study found reduced post-operative analgesic requirement. Another promising technique was drainage, although this alternative raises concerns regarding complications. The use of intraperitoneal local anaesthetics had limited effect on the incidence and severity of SP. Intraperitoneal saline on the other hand had an effect, but the evidence is limited to two studies.

Several causes of SP after laparoscopic surgery have been reported in the literature, but the leading hypothesis is based on carbon dioxide (CO_2) in the abdominal cavity. It is thought that pneumoperitoneum causes diaphragmatic irritation by overstretching the diaphragmatic muscle fibres resulting in a pain sensation mediated by the phrenic nerve [23]. Jackson et al. investigated the association between the dimension of the gas bubbles in the peritoneal cavity and the severity of pain and found a correlation between the residual gas volume and post-laparoscopic pain [23]. To support the theory of overstretched diaphragmatic muscle fibres, it has also been shown that low insufflation rate reduces post-operative SP [24]. Rapid distension is associated with tearing of blood vessels, traumatic traction of the nerves and release of inflammatory mediators [6] leading to post-operative pain.

Intraperitoneal administration of local anaesthetics has been evaluated for several different laparoscopic procedures [25–29]. It is based on the theory that the instillation of local anaesthetics in the peritoneal cavity blocks the visceral afferent signalling, thereby resulting in reduced nociception [30]. The literature presented in this review does not support the use of local anaesthetics for SP reduction in benign gynaecological laparoscopy. None of the studies could demonstrate a reduction in incidence, and only two out of six studies reported a significant reduction in the severity of SP [10, 14]. Despite this, three out of six studies found a significant reduction of post-operative analgesic consumption [10, 11, 14]. The present evidence does not support a widespread use of intraperitoneal local anaesthetics in benign gynaecological laparoscopy for reduction of SP. Besides a local effect in the peritoneal cavity, the analgesic effect of intraperitoneal local anaesthetics could also be mediated through systemic absorption. There are measurable plasma levels of local anaesthetics shortly after

Table 2 The effect of pulmonary recruitment manoeuvre (PRM) on the incidence and severity of shoulder pain (SP)

Reference	Publication year	Number	Procedure	Intervention	Incidence of SP	Severity of SP	Post-operative analgesics
Phelps et al. [5]	2008	100, 46/54	Elective outpatient gynaecologic surgery	PRM vs. nothing	↓	–	N/A
Sharami et al. [16]	2010	131, 67/64	Minor laparoscopic gynaecologic surgery	PRM vs. nothing	↓	↓	↓
Tsai et al. [8]	2011	104, 53/51	Laparoscopic surgery for benign gynaecologic lesions	PRM vs. nothing	↓	↓	–
Tsai et al. [8]	2011	107, 53/54	Laparoscopic surgery for benign gynaecologic lesions	PRM vs. INSI	↑	↑	–

N/A not available, ↓ significant decrease, ↑ significant increase, – not significant

intraperitoneal administration due to absorption over the peritoneal surface. A potential risk with administration of intraperitoneal local anaesthetics is that the dosage is difficult to control. Although plasma levels of local anaesthetics have been reported to be close to and above safe threshold, no clinical toxicity or adverse effects have thus far been reported [31]. It cannot be ruled out that local anaesthetics can be used to reduce SP after laparoscopic surgery for benign gynaecological disease, but further studies are warranted before a general recommendation can be made.

The most promising data were found in the studies evaluating the effect of PRM. PRM was associated with an overall reduction in both the incidence and the severity of SP [5, 8, 16]. PRM works by removing residual CO_2 from the peritoneal cavity by manually delivering pulmonary inflations with a pressure of between 40 and 60 cmH_20. The positive pressure causes the lungs to expand and the diaphragm to descend, resulting in the evacuation of residual CO_2 from the peritoneal cavity [5, 8, 16]. There is heterogeneity concerning the maximal pressure used during inflation. One study applied a pressure of 60 cmH_20 [5]. Although there are concerns that this ventilation pressure can result in pneumothorax, the authors did not report any cardiovascular or pulmonary complications. Another study applied the PRM technique with a reduced pressure (40 cmH_2O) and also found a significant reduction in the incidence and severity of SP without cardiovascular or pulmonary complications [16]. Thus, it seems that a significant reduction in SP can be achieved with lower pressures, thus minimising the potential risk of complications. One of the studies which applied the PRM technique also compared PRM to intraperitoneal saline. This study arm reported a reduction in both the incidence and severity of SP when saline was compared to PRM. The authors hypothesised that this reduction is due to a longer lasting effect of intraperitoneal saline compared to PRM. A possible explanation of this longer lasting effect is that intraperitoneal saline acts as a buffer system. The CO_2 in the abdominal cavity resolves in the water and becomes carbonic acid. From here, the carbonic acid is transformed to bicarbonate through the red blood cell in the intravascular space. In the lungs, the bicarbonate is again transformed to CO_2 which is exhaled by the patient [8].

Intraperitoneal drainage was also associated with a reduction in both the incidence and severity of SP [17–19]. The application of a drain to reduce SP is based on the assumption that it allows residual CO_2 to be removed from the abdominal cavity. Open and closed suction drainage was associated with a reduction in the severity [17, 18] and incidence of SP [18, 19]. In two of the three RCTs, there was also a reduction in the post-operative analgesic requirements [18, 19]. However, it can be discussed if it is a cost-effective and safe procedure [19]. Although there were no complications reported in any of the studies [17–19], the use of drains can potentially lead to complications such as wound infections, increased abdominal wall pain, decreased pulmonary function, restricted mobilisation and prolonged hospital stay [32]. With the application of PRM, which is also based on removing residual CO_2

Table 3 The effect of drainage on the incidence and severity of shoulder pain (SP)

Reference	Publication year	Number	Procedure	Intervention	Incidence of SP	Severity of SP	Post-operative analgesics
Swift et al. [17]	2002	67, 30/37	Laparoscopic gynaecologic surgery for benign disease	Open drain 4 h post-operatively	N/A	↓	N/A
Abbott et al. [19]	2001	161, 82/79	Diagnostic/minor gynaecologic laparoscopy	Open drain 4 h post-operatively	N/A	↓	↓
Shen et al. [18]	2003	164, 80/84	Laparoscopic assisted vaginal hysterectomy	Closed suction drainage	↓	↓	↓

N/A not available, ↓ significant decrease

Table 4 The effect other interventions on the incidence and severity of shoulder pain (SP)

Reference	Publication year	Number	Procedure	Intervention	Incidence of SP	Severity of SP	Post-operative analgesics
Guido et al. [22]	1998	54, 30/24	Laparoscopic tubal ligation	Gasless laparoscopy with Laprolift®	N/A	–	N/A
Ghezzi et al. [21]	2011	76, 38/38	Hysterectomy	Minilaparoscopic vs. conventional hysterectomy	N/A	–	–
Tsai et al. [8]	2011	106, 54/51	Laparoscopic surgery for benign gynaecologic lesions	Saline instillation	↓	↓	–
Suginami et al. [20]	2009	40, 21/19	Laparoscopic gynaecologic surgery	Saline instillation	N/A	↓	–

N/A not available, ↓ significant decrease, – not significant

from the abdominal cavity, none of these complications exist. In addition, the PRM technique can be performed in a much shorter time duration compared to drainage and allows for faster mobilisation. Thus, it seems that for removing residual CO_2, the PRM technique is favourable compared to drainage with respect to ease of implementation and potential post-operative complications.

Another technique that is also based on removing residual CO_2 from the abdominal cavity is intraperitoneal saline instillation. Intraperitoneal saline instillation is believed to reduce SP by two different mechanisms of action. First, it increases the intraperitoneal pressure which displaces the residual carbon dioxide from the peritoneal cavity. Secondly, it acts as a physiological buffer whereby the residual carbon dioxide is dissolved [8, 20]. Both RCTs evaluating this technique found a significant reduction in the severity of SP, and Tsai et al. also found a significant reduction in the incidence of SP. In this study, they even found that saline instillation was more effective than the PRM technique [8]. In this systematic review, all studies, except one evaluating local anaesthetics, used a placebo group with intraperitoneal saline. The fact that saline does seem to reduce SP could account for the discouraging results found in the studies comparing local anaesthetics vs. saline. In our opinion, future studies evaluating local anaesthetics should primarily compare it to a control group using no instillation. The pain-reducing effect of saline may be due to the buffer system described above as well as to the displacement of trapped CO_2 from the peritoneal cavity at the end of surgery.

Gasless laparoscopy performed with Laprolift® is an alternative surgical technique to conventional laparoscopy with pneumoperitoneum. The technique eliminates the effect of residual CO_2 in the peritoneal cavity completely. Despite this, no reduction in SP severity could be found in this study [22]. The occurrence of SP without pneumoperitoneum indicates that the pathogenesis of SP is complex and multifactorial. This technique is particularly indicated in elderly patients with pulmonary/cardiac comorbidities, where increased abdominal pressure and the use of CO_2 can have potential side effects.

The last study aimed to reduce post-operative pain by minimising the surgical trauma. This study compared the effect of minilaparoscopy vs. conventional laparoscopic hysterectomy and did not report a significant difference in the severity of SP. Keeping in mind the hypnotised pathogeneses for SP, this technique should have a little impact on SP as the only difference between the two techniques is the port sizes (port size of 3 vs. 5 mm) [21].

There are several limitations to this systematic review. Due to the heterogeneity of the included studies, it is difficult to compare them and impossible to perform a meta-analyses. Another limitation is the quality. Outcome parameters were often not clearly defined. Evaluation of sample size and power calculation was not performed in all the included studies. Most RCTs included in this review did not describe in detail how they assessed pain (during rest/coughing/mobilisation) neither did they describe the timing of VAS measurements. Description of the inclusion and exclusion criteria were not well defined or not reported at all. Another point of limitation is that some studies did not report the indication for laparoscopic surgery. Finally, this systematic review used language restriction. Only studies written in English were included. This may introduce language bias and lead to erroneous conclusions.

Several different techniques to reduce SP have been evaluated in the literature. A definite conclusion is difficult based on the retrieved evidence presented. This was due to the heterogeneity of the included studies, the study size and the quality of included studies. Overall the pulmonary recruitment manoeuvre and drainage show promising results in reducing both the incidence and severity of SP. In an era of fast-track surgery with early mobilisation, the routine use of drainage is not recommended and only increases the risk of post-operative complications. Another promising method is intraperitoneal saline, although the evidence is too weak to make any definite conclusions. The results presented in this review do not support the use of intraperitoneal local anaesthetics.

Other hypothesis of reducing peritoneal damage during laparoscopic surgery is to keep the peritoneal surface moist

by changing the condition of the gas for pneumoperitoneum. Applying CO_2 at body temperature and humidified condition is close to the homeostatic condition of the peritoneal cavity which is thought to be more physiologic and less damaging to the peritoneal cavity. Future studies need to elucidate this hypothesis [33].

In conclusion, based on the findings in this review, PRM using a pressure of 40 cmH_2O can be recommended as a simple and cost-effective method to reduce SP after laparoscopy for benign gynaecological disease. However, it is not possible to make a definite conclusion concerning the clinical effects and larger well-designed trials are needed to investigate the most appropriate technique.

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