

Omalgia in Laparoscopic Kidney Surgery

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Abstract

Minimal invasive surgery has well-known advantages. The majority of procedures performed on the kidney are now-a-days laparoscopic, with several advantages over laparotomy: decreased perioperative morbidity and mortality, smaller incisions, faster recovery, shorter hospital stays and earlier return to active life. Postoperative pain is the most common complaint and an important issue following laparoscopic surgery. There are different theories proposed to explain omalgia: distension of the peritoneal blood vessels and nerves during pneumoperitoneum, the associated inflammatory reaction (release of proinflammatory cytokines), rate of CO₂ infusion; distension of the triangular and round ligament; time of exposure to the gas; gas retention inducing irritation of the phrenic nerve; nerve injury during patient positioning (shoulder abduction) and diaphragm injury. Debate still exists on how to minimize it. We review the different etiologic mechanisms and proven and potential preventive measures and treatments on how to avoid post-operative pain: proper patient positioning, pulmonary recruitment maneuvers, intraperitoneal normal saline infusion, using gabapentin, pregabalin, irrigation with bupivacaine, using NSAIDs, opioids and hydrocortisone.

Keywords: Omalgia; Laparoscopic urology; Kidney

Objective

To present an updated organized description of laparoscopic-induced omalgia, its clinical manifestations, physiopathology, management and preventive measures with focus in laparoscopic urology.

Introduction

The kidneys are retroperitoneal organs, whose position varies greatly by side, degree of inspiration, body position, and presence of anatomic anomalies. The right kidney is 1-2 cm lower than the left one, owing this displacement to the liver, usually in the space between the top of the first lumbar vertebra and to the bottom of the third lumbar vertebra. The left's upper limit is at the body of the 12th thoracic vertebra down to the body of the third lumbar vertebra [1]. The kidney is surrounded, in its upper third, posteriorly, by the diaphragm and the 12th rib, with the pleura reaching its lower border. The psoas muscle, the quadratus lumborum and the aponeurosis of the transversus abdominis muscle surround the middle and lower third of the kidneys. The anterior plane is different on the right: from cranial to caudal we have the liver, the right adrenal gland, the descending duodenum, and the hepatic flexure of the colon. On the left, we have the tail of the pancreas on top, the splenic vessels, the left adrenal gland and the spleen. The lower third is related to the splenic flexure of the colon. The perirenal fascia is called Gerota and it envelops the kidney on all aspects except inferiorly, remaining an open potential space. Classical open surgical approaches to this organ have been through the flank, without violating the peritoneal cavity.

Laparoscopic surgery is a well-established procedure in urology for a variety of procedures: nephrectomy (partial, radical, living-donor), nephroureterectomy, pyeloplasty, radical prostatectomy, pelvic lymph node dissection, varicocelectomy and total cystectomy with ileal conduit formation [2], with the first laparoscopic nephrectomy being performed and described by Clayman in 1991 using the transperitoneal approach, soon followed by advances in retroperitoneoscopy [3]. Laparoscopic nephrectomy is now standard of care for removal of renal tumours, non-functioning kidneys and in some centres it's the main procedure for donor kidney retrieval [4]. It reduces tissue trauma, causes less postoperative pain with better cosmetic results and shorter hospital stays [1].

Most laparoscopic nephrectomies are performed in the lateral

decubitus position with a kidney rest just above the iliac crest, with hyperextension of the loin over the table break and the upper arm suspended above the patient, outstretched on an overarm rest or pillow. The patient can be placed in the full lateral decubitus position for extraperitoneal approaches or a modified 45° lateral decubitus position for intraperitoneal procedures, with intra-abdominal insufflation of CO₂ and its attendant effects, having the potential outcome of being converted to an open surgery [5]. Through intra-abdominal insufflation of CO₂, a pneumoperitoneum is created setting up a working space for the surgeon. The currently preferred gas, carbon dioxide, is odorless, not combustible, rapidly absorbed, safe, low cost, and has the ability to suppress combustion [6,7]. Access to the peritoneum can be performed via either a closed (by placing a Veress Needle) or an open technique (with a Hasson cannula commonly placed at the umbilicus). To maintain a tense pneumoperitoneum during port placement, carbon dioxide insufflation pressures are often temporarily increased to 20 mm Hg [8]. Anesthesia is commonly used to facilitate urological procedures, with many urological patients being elderly with multiple co-morbidities. It may encompass local, monitored anesthesia care, regional or general techniques [9], sometimes demanding extensive resources intra and postoperatively. Postoperative pain management in the form of epidural or patient controlled multimodal analgesia may be essential and high-dependency care in a post-operative setting is beneficial in major urological surgery.

Shoulder pain (omalgia) is rare in laparotomy but common in laparoscopic surgery (35-80%) [10-13] sometimes are being very serious and severe. It may be transient or persist for about 3 days [14] very rarely persisting after this time-frame, but sometimes causing more discomfort to the patient than the incisions sites. It contributes to patient morbidity and an increased analgesic requirement post-operatively. It was reported as the most common cause for delay in

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discharge after day-case laparoscopy [15,16]. Management is not standardized, without any reliable methods validated yet [13]. Epidural anesthesia alone is insufficient as an analgesic method [17]. Besides the pain, brachial plexus injuries from bad positioning may lead to a sensory deficit in the shoulder area, as well motor impairment on upper arm abduction [18]. Besides shoulder pain, other possible complications from laparoscopic nephrectomy are: sepsis, bowel injury, rhabdomyolysis and acute renal failure, or even having the procedure converted to an open one [4,5].

Material and Methods

We performed a literature search through the Medline database, between 2000 and 2014, concerning the following search terms: "shoulder pain", "shoulder-tip pain", "urologic" and "laparoscopy", in the month of October. We identified original articles, review articles, and editorials addressing shoulder pain in a perioperative setting. Only articles published in the English language were selected. Publications and relevant references before the year 2000 were also retrieved. Publications not concerning humans were not considered, and both genders were included. Two independent reviewers selected all relevant articles. The authors eliminated independently and simultaneously all duplicates. The relevant articles were selected on the basis of reading the full text manuscripts. The eligibility criteria for inclusion were based on relevance concerning the online electronic literature search involved unrestricted, fully explored Medical Subject Headings (MeSH) using terms related to shoulder pain, severity of shoulder pain on any scale and its management in a post-operative setting, after laparoscopic urologic procedures. If there was any doubt concerning the eligibility of a study, abstracts-and if necessary, the full texts-were examined. If disagreement regarding inclusion occurred, an agreement was reached by discussion. Additional references were identified from the reference lists of these articles.

Physiopathology of Omalgia

There are some important factors to consider with important physiopathological alterations related to omalgia: carbon dioxide insufflation, its absorption into the blood stream and the lateral lithotomy patient positioning [19,20]. Specific mechanisms were suggested to explain omalgia: distension of the peritoneal blood vessels and nerves by pneumoperitoneum, with an associated inflammatory reaction (the release of proinflammatory cytokines [21-23]; the (elevated) rate of CO₂ infusion, with important distension of the triangular and round ligament; the time of exposure to the gas; carbon dioxide retention inducing irritation of the phrenic nerve; nerve injury during patient positioning (shoulder abduction) and, finally, diaphragm injury [24-29]. Shoulder pain is usually a referred pain; it's typically well localized, occurring when visceral afferents that carry stimuli from a diseased organ enter the spinal cord along with the somatic afferents from a remote anatomic location [30]. In spite of being well recognized and directly attributed to carbon dioxide, shoulder pain may also occur during gasless laparoscopic surgery [31,32].

Pneumoperitoneum Distension and Residual Carbon Dioxide

The carbon dioxide is used to inflate the abdominal cavity for better visualization, creating a working surgical field. The presence of residual carbon dioxide is one of the main hypotheses appointed as the cause responsible for postoperative shoulder pain following a laparoscopic procedure [33,34], but not all studies confirm that [35]. Carbon dioxide remains in the sub-diaphragmatic space after laparoscopy and it's converted to carbonic acid on the moist peritoneal surfaces [36].

It irritates the diaphragm and phrenic nerve by local acidosis causing referred pain to the C₄ dermatome with consequent shoulder pain [28,29,37,38]. The duration of post-laparoscopic pneumoperitoneum is also appointed as a possible cause; it's not well defined as there are only a few studies published on the rate of absorption and disappearance of the residual carbon dioxide in the peritoneal cavity following laparoscopic procedures. Two studies with up to 30 patients each point to a rate of 10-70, 4% of patients with an immediate residual post-operative pneumoperitoneum [34,39,40]. In papers with longer follow-ups, almost all patients cleared their residual postoperative pneumoperitoneum within 1 week of their procedure [36,41]. The longest period of postoperative pneumoperitoneum was reported by Ceydeli et al., when it persisted for more than 8 weeks [42]. The correlation between the duration of post-operative pneumoperitoneum and shoulder pain is still not clear [36].

Shoulder Abduction during Surgery

Nerve injuries constitute almost one third of anesthesia-related medical legal claims in the United States [43]. A review published by Wolf et al., in Urology, concerning shoulder pain in upper retroperitoneal procedures identified only 3 patients complaining of shoulder pain out of 1246 surgeries. Abdominal wall neuralgias, which were defined as dysesthesia, hyperesthesia, or hypoesthesia radiating from a port site, were the most common injuries [44]. Ipsilateral shoulder pain was as uncommon as back pain, and attributed to contusion of the shoulder joint or supracapsular nerve injury (during positioning) rather than referred pain from diaphragmatic irritation by carbon dioxide or even operative trauma. Shoulder pain, along with rhabdomyolysis (severe pain and tenderness of the flank, back, hip, or thigh that had been in contact with the operating room table) were the only complications that were always noted within the first 2 post-operative days, and all of the three ipsilateral shoulder injuries occurred in the flank position. In a more recent paper, using the registries of Insurance company claims, the "American Society of Anesthesiologists Closed Claims Project" [45] collecting more than 4000 claims, found that nerve complications represented 16% of the complaints. Of these, 20% involved the brachial plexus.

A few observational studies [46-49] have reported postoperative peripheral neuropathies occurring in patients with specific preexisting conditions (e.g., diabetes mellitus, vascular disease, body mass index, and age). A work by Agostini et al. [18] states that thin patients are more vulnerable to injury because they don't have a cushion of protective subcutaneous fat. Also, the use of shoulder braces in surgical positioning is also said to contribute to stretch-induced neuropathy of the brachial plexus and median nerve [50]. While these lesions are not permanent, post-injury recovery may take as much as a year [18]. The precise mechanism of shoulder pain still eludes clinicians.

Rate of CO₂ Infusion and Intraoperative Pressure

Lower pain scores were identified in patients that, during surgery, maintained a low-pressure pneumoperitoneum, defined as 8-9 mm Hg. Dissection is more difficult, surgery takes longer, with increased hemorrhage volume and higher gas consumption; in spite of this, some authors recommend it as an option to be considered, as the frequency and the intensity of shoulder tip pain are significantly reduced [51-54]. In a similar work, Ekstein et al. [55], showed that with an intrabdominal pressure superior to 15 mm Hg, the post-operative analgesic requirements, as well as pulmonary and cardiovascular complications also increase. A lot of different methods have been tried besides low pressure insufflation: slow rate of insufflation, using no carbon dioxide

(gasless laparoscopy) or warming up the insufflation gas [56,57] but recommendations cannot be made.

Type of Gas

As stated before, carbon dioxide (CO₂) is the most popular alternative for therapeutic pneumoperitoneum. Before carbon dioxide, nitrous oxide (N₂O) was usually used: it's inexpensive, rapidly eliminated with diffusion and solubility rates similar to CO₂, with fewer cardiopulmonary side effects. The main disadvantages are that it doesn't suppress or support combustion, and two anecdotal reports were published describing intraoperative explosions. These events caused it to be discontinued and replaced by carbon dioxide. A paper by Tsereteli et al. [57], from 2002 showed that N₂O can be a safe alternative to carbon dioxide in creating a pneumoperitoneum for laparoscopic surgery with less postoperative pain, especially in the elderly, prolonged operations or patients with preexisting cardiopulmonary dysfunction. The same conclusions were obtained from Sharp et al. [58], Aitola et al. [59] and Minoli et al. [60].

Type of Procedure

The type of laparoscopic procedure performed does not appear to significantly influence the rate of resolution of the postoperative residual pneumoperitoneum so it's probably safe to assume these data can be extrapolated to the laparoscopic nephrectomy.

Prevention

A focused preoperative medical history and a thorough physical assessment may identify patients with an increased risk for the development of peripheral neuropathies during the perioperative period, with special attention to body habitus, preexisting neurologic symptoms, diabetes, peripheral vascular disease, alcohol dependence, and arthritis [61]. Proper patient positioning besides giving surgeons access to the pelvic and retroperitoneal organs is a critical part of every surgical procedure when comes to minimizing the risk of iatrogenic injuries as peripheral nerve damage and compartment syndrome. A special task force of ASA (American Society of Anesthesiologists) published in 2011 a practice advisory to reduce the frequency and minimize the severity of peripheral neuropathies that may be related to perioperative positioning of patients [62]. It concerns specifically the proper use of protective padding and avoidance of contact with surfaces. They recommend the use of padded arm, elbow boards and chest rolls to decrease the risk of upper extremity neuropathy. The inappropriate use of padding (e.g., padding too tight) may increase the risk of perioperative neuropathy. If the arm is taped, care must be taken to avoid the elbow or the radial groove in the upper one third of the humerus to avoid the ulnar or radial nerve. If the arm board is not in line with the arm, the proximal edge can also damage these nerves by stretch or compression [63]. The lower chest should be supported by an axillary roll in order to prevent compression of the axilla and shoulder, and avoid tension on the brachial plexus of the dependent upper extremity. The head should be in a straight position with arms in a physiologically neutral position, rotated medially, and be either tucked under the draw sheet or placed laterally, abducted no more than 90° on adequately supported arm rests to avoid dorsal hyperextension and prevent brachial plexus injury. Failure to do so, by hyperabduction of the shoulder, external rotation and dorsal extension of the arm, or flexion of the head to the contralateral side can or will predispose the patient to brachial plexus injuries from compression of the plexus by the head of the humerus, the first rib, and the clavicle [64]. A simple postoperative assessment of extremity nerve function is recommended, as it may lead to early recognition of peripheral neuropathies. Patients

should be encouraged to lose weight if elevated BMI, because of the risk of both neural and vascular mediated injury. Also, optimal medical management of diseases like diabetes and peripheral vascular disease is essential as the risk for compression and perfusion injuries is bigger. Sukhu et al. [50] state that communication with the anesthesia team is essential. It's important for high-risk patients to have multiple positioning checks, shortened operative time and optimal fluid management. Also, lack of operative experience contributes to the risk of injury, with neuromuscular injuries being more common in low volume centers [13].

Pulmonary Recruitment Maneuver (PRM) and Intraperitoneal Normal Saline Infusion (INSI)

The most logical technique to reduce shoulder pain seems to be to allow the CO₂ gas to escape from the peritoneal cavity [45]. Removing or washing out residual carbon dioxide might help to reduce the incidence and intensity of both shoulder and upper abdominal pain [65]. The pulmonary recruitment maneuver works by mechanically increasing intraperitoneal pressure (by means of positive-pressure ventilations, inflating the lungs and lowering the diaphragm) [12] facilitating the removal of residual carbon dioxide from the peritoneal cavity immediately after surgery, resulting in less intra-abdominal acidosis and less phrenic nerve or peritoneal irritation [14]. The setback is that it has a transient and not persistent effect. Phelps et al. [66] and Sharami et al. [26] came to the same conclusions, using different pressure settings but Khanna et al. believe that it should be considered at the end of all laparoscopic procedures [67]. The INSI is also used to reduce laparoscopy-induced pain. It works by increasing intraperitoneal pressure, similar to PRM while also offering a physiologic buffer system to dissolve excess carbon dioxide. Warm isotonic saline is left at the abdominal cavity (about 25-30 mL/Kg of body weight) [14]. Carbon dioxide dissolves in water and forms carbonic acid, which is absorbed into the intravascular space, it contacts with red blood cells, where carbonic anhydrase transforms carbonic acid into bicarbonate, which is finally expelled at the lung as carbon dioxide. It is a safe proven method [68-70]. It is still difficult to make any hard recommendation concerning a residual post-operative pneumoperitoneum (RPP), as the literature is hardly comparable: RPP is lower in obese patients than in asthenic ones [42,71,72] and age and gender differences seem to have no effect on the RPP [73-76].

Drain Insertion

When concerning drains, and based on radiographic sampling, it seems that drains have little effect on the incidence of postoperative pneumoperitoneum. Others, based on CT, show that a greater incidence of pneumoperitoneum was found in patients with one or more drains compared with those without a drain. Air bubbles were observed adjacent to the drain in several cases, suggesting that air enters the peritoneal cavity along the drainage tract. Additional parameters, including duration of surgery, the presence and location of an anastomosis (either in the abdominal cavity or in the pelvis), the time to flatus, and time to first bowel movement were evaluated in a recent study. No correlation was found between any of these parameters and the time to disappearance of RPP [77].

NSAIDs and Opioids

Figuroa-Balderas et al. published, in 2013, a double-blind, randomized clinical trial in patients undergoing laparoscopic cholecystectomy to assess the reduction of post-operative omalgia comparing ketorolac and ketorolac with acetazolamide, totaling 62 patients. They found that the administration of 250 mg of acetazolamide,

30 minutes before anesthetic induction, along with ketorolac, reduces omalgia in the post-operative setting [75]. NSAIDs are often used during surgery and in the post-operative period, with analgesic properties comparable to those of opioid compounds, but without opioid-related side-effects [78]. They are considered an established therapy in reducing shoulder pain [68,79,80], but sometimes with conflicting results [81].

Hydrocortisone

Sarvestani et al., published in 2013 a prospective study concerning cohort of 60 adult patients undergoing laparoscopic cholecystectomy, randomized to receive an intraperitoneal administration of 100 mg of hydrocortisone vs. placebo. Abdominal and shoulder pain scores were significantly lower in the hydrocortisone group postoperatively as were requirements for parenteral opioids afterwards [79].

Bupivacaine and Ropivacaine Irrigation

Cuniffe et al. [16] showed that intraperitoneal irrigation with bupivacaine to both hemidiaphragms at the end of surgery, without additional difficulty or significant extra operating time, proved to be a reliable method in reducing frequency and intensity shoulder tip pain, with a great potential to reduce patient morbidity. Ropivacaine, administered in a similar fashion was ineffective in reducing shoulder tip pain [80]. Local anesthetic distribution may not always be uniform throughout the peritoneal surface. Ingelmo et al. [81] defended the intraperitoneal nebulization with a local anesthetic providing uniform dispersion of the anesthetic particles throughout the peritoneal cavity. Along with Alkhamisi and colleagues [82] and Bucciero et al. [83] they found that ropivacaine nebulization (either preoperative or postoperative) significantly reduced postoperative pain, referred shoulder pain and opioid requirements.

Gabapentin and Pregabalin

Gabapentin and Pregabalin are antiepileptic drugs also used to treat chronic pain. They are both structural analogues of the inhibitory neurotransmitter γ -aminobutyric acid. They are responsible for inhibition of calcium influx and reduced neurotransmitter release of glutamine, norepinephrine, and substance P at the central nervous system, with suppression of neuronal excitability after nerve or tissue injury [84]. They have proven to be effective in reducing post-operative pain and opioid consumption [85], but studies concerning shoulder pain are still very few and inconclusive [86]. In a recent study, 56 women undergoing elective laparoscopic gynecologic surgery were randomly selected to receive 75 mg pregabalin before and after surgery or the same dosage and frequency of placebo. According to VAS (Visual analog scale) scores, shoulder pain and surgical pain were significantly lower in the pregabalin group with decreased postoperative analgesic requirements [87].

These results should be interpreted in light of some limitations that we believe, still acceptable to arrive to our conclusions. First, this is a retrospective review with variables changing from hospital to hospital. Comparison is difficult because of different methodologies applied, with different procedures and surgeries being covered; can we extrapolate the data to omalgia following laparoscopic nephrectomy? We believe the mechanisms in play are similar in the majority of abdominal laparoscopic surgery, as enunciated above, when a pneumoperitoneum is developed, but specific procedures of each surgery may preclude further conclusions. Evidence-based based studies are needed to yield strong conclusions.

There is no technical effective way of estimating residual

pneumoperitoneum volume, as well as other gas, products of tissue combustion, but probably these factors won't influence postoperative pain.

The visual analogic scale (VAS) is subjective, consisting in a horizontal or vertical line with 10 cm de longitude between two set points. One (score 0) refers to the expression "no pain", the other (score 10) to the "maximum pain ever felt". It is the patient who chooses the score that best reflects the pain he is experiencing.

Finally, some studies reviewed were performed as a day case surgery (or on an ambulatory setting) while others were related to in-patients. The day surgery regime is different from hospital to hospital.

Conclusions

Laparoscopic surgery is a well-established procedure in urology for a variety of procedures, with shoulder pain being a common event in the post-operative setting. Urologists, anesthesiologists, and all operative staff must be familiar with risk factors for positional injuries and prevention of such injuries must be actively sought. Proper communication channels between staff are essential. A complete preoperative history of risk factors such as diabetes or vascular disease as well as ASA classification is imperative. Management of shoulder pain is still empiric and a multitude of options exist and are being developed, with further studies in this are still needed.

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