



Original Article

The Pattern of Causes of Pneumoperitoneum-induced Peritonitis: Results of an Empirical Study



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ARTICLE INFO

Article history:

Received 28 February 2016
 Received in revised form 29 April 2016
 Accepted 30 April 2016
 Available online 7 May 2016

Keywords:

Pneumoperitoneum
 Peritonitis
 exploratory laparotomy
 Perforation
 Non-Surgical

ABSTRACT

Pneumoperitoneum refers to presence of free air within the peritoneal cavity, “Pneumoperitoneum induced Peritonitis” is synonymous of surgical pneumoperitoneum, as the leak of air and visceral contents contaminates the peritoneal cavity, producing peritonitis which mandates surgery. This entire pneumoperitoneum may result from inflammatory conditions, traumatic injury, neoplasia, anastomotic leak and vascular causes.

The objectives of this study is to determine the incidence of Pneumoperitoneum-induced Peritonitis (surgical pneumoperitoneum) in emergency exploratory laparotomies, to identify the common anatomical sites of perforations and to review the pathological etiology of these cases.

Review of 450 cases of emergency exploratory laparotomy cases performed in King Abdulaziz University Hospital from January 2011 to December 2015, among them 131 cases with radiologically documented pneumoperitoneum were selected to be involved in the study of surgical pneumoperitoneum, the anatomical site of perforation and the exact underlying pathology were documented.

29% of exploratory laparotomy cases were found to have pneumoperitoneum, mainly in the in the gastroduodenal region, inflammatory conditions as peptic ulcer disease or diverticulitis were the underlying cause of most of perforations.

Pneumoperitoneum frequently indicates bowel injury or disease, hence it is called surgical pneumoperitoneum, Perforations are commonly found in gastro-duodenal area, the inflammatory conditions are responsible for the vast majority of cases, however presence of air with intact bowel, is called Non-Surgical or spontaneous Pneumoperitoneum, which has to be approached conservatively.

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1. Introduction

Pneumoperitoneum is defined as presence of free air within the peritoneal cavity [1], “Pneumoperitoneum induced Peritonitis” is synonymous of surgical pneumoperitoneum, when leak of air and visceral contents contaminates the peritoneal cavity producing peritonitis that mandates surgery, this entire pneumoperitoneum

may result from inflammatory conditions, traumatic injury, neoplasia, anastomotic leak and vascular causes, therefore presence of free air in the peritoneum with intact gut is known as “Non-Surgical or Spontaneous Pneumoperitoneum” [2], which is usually treated conservatively, that condition should be clear in assessment of abdominal cases to avoid unnecessary operation [3].

The objective of this study is to determine the incidence of pneumoperitoneum-induced peritonitis (surgical pneumoperitoneum) among all cases of acute abdomen managed by emergency exploratory laparotomy in our

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practice, and to identify the common anatomical sites of perforations, as well as the pathological etiology of these cases, that may offer a help to plan for appropriate surgery.

2. Material & methods

This retrospective study reviewed all emergency exploratory laparotomy cases performed in King Abdulaziz University Hospital, from January 2011 to December 2015, among them only radiologically documented pneumoperitoneum cases were selected to be involved in the study, and labeled as surgical pneumoperitoneum or pneumoperitoneum-induced peritonitis.

Assessment and resuscitations with the initial investigations were carried out by the surgical on-call team, before transfer to the operation theatre, where formal exploratory laparotomy was performed, (peritoneal lavage, culture swab from the peritoneal exudate, routine exploration of the whole abdomen, management of the perforation accordingly, finally washing the peritoneal cavity with normal saline and insertion of drains before closure). All specimens as edges of perforation or the whole resected segments were sent to histopathology.

The exact anatomical site of perforation was defined during surgery, while the final etiological diagnosis was reported by histopathology, all demographic and clinical data of each patient were collected and analyzed by IBM-SPSS version 22, approval of the study was obtained from the Hospital Ethical Committee before start.

3. Results

This retrospective study reviewed 450 emergency exploratory laparotomy cases, 131 out of 450 cases of exploration were with radiologically documented pneumoperitoneum (29%).

The demographic data of surgical pneumoperitoneum cases showed that age ranged between 18–88 years, the mean, median and mode of age were 45.1, 54, 51 years respectively, males were predominant in the study 84/131 (64.1%) while females account 47/131 (35.9%). [Table 1](#)

The anatomical diagnosis of surgical pneumoperitoneum cases was defined during the exploratory laparotomy, that showed high prevalence of perforations was in the gastroduodenal region (55/131 about 42%), while in 28 cases, perforations were found in the small bowel (21.4%), as well as 41 cases out of 131 pneumoperitoneum cases were discovered in the large bowel (31.3%), only 7 cases illustrated appendix as the course of pneumoperitoneum (5.3%). [Table 2](#)

The pathological etiology was disclosed by the histopathological examination which reported that the inflammatory conditions were responsible for perforation in 79 cases (60.3%), while history of trauma and

Table 1
Gender Distribution in Surgical Pneumoperitoneum Cases.

	Males	Females	Total
Number of Patients	84	47	131
Percentage	64.1%	35.9%	100%

Table 2
The Anatomical Sites of Surgical Pneumoperitoneum.

	Number of Patients	Percentage
Gastroduodenal	55/131	42%
small bowel	28/131	21.4%
large bowel	41/131	31.3%
Appendix	7/131	5.3%
Total	131	100%

Table 3
The Pathological Etiology of Surgical Pneumoperitoneum.

	Number of Patients	Percentage
Inflammatory conditions	79/131	60.3%
Trauma	22/131	16.8%
Post-operative Leak	9/131	6.9%
Neoplasia	8/131	6.1%
Ischemia and Vasculopathy.	13/131	9.9%
Total	131	100%

post-operative leak were found to be the causes in 22,9 cases, that account (16.8%), (6.9%) respectively, their histopathological examination did not show any chronic inflammatory or neoplastic cells and also denied any ischemic changes in these cases. Therefore neoplastic cells were found in 8/131 cases, on the other hand 13/131 cases (9.9%) had evident ischemic changes and vasculopathy. [Table 3](#)

4. Discussion

The peritoneum is a thin and serous membrane that lines the abdominal cavity, it is formed of two layers; parietal and visceral layers, the former lines the abdominal wall while the latter reflects over the abdominal viscera. Several intra-abdominal organs are enclosed by visceral peritoneum to such an extent that they are almost completely covered by peritoneum, they are called intra-peritoneal structures; they have double layers of peritoneum within them as mesenteries and ligaments. A thin layer of serous fluid, which acts as a lubricant, separates the two layers [4].

The term pneumoperitoneum refers to the presence of air within the peritoneal cavity, two different pathologies are resulted from this condition, Surgical Pneumoperitoneum, which usually indicates bowel perforation [5], the other type is, Non-surgical or Spontaneous Pneumoperitoneum, which refers to the existence of air intraperitoneally without bowel perforation.

Surgical Pneumoperitoneum can be expressed as Pneumoperitoneum-induced Peritonitis, as the leak of air and gut content results in that serious condition, which requires emergent surgical management. The radiological finding of free air in the peritoneum is usually sign of intraperitoneal disease or injury.

Surgical pneumoperitoneum represents 85–90% of all pneumoperitoneum cases, while the Non-surgical form accounts 5–15% of all occurrences [6]. Another incidence was illustrated in this study, which is the incidence of pneumoperitoneum in emergency exploratory laparotomy. Our review has demonstrated that 29.1% of all emergency laparotomies were found to have perforated viscus.

Table 4

The Inflammatory Causes of Surgical Pneumoperitoneum.

	Gastroduodenal	diverticulitis	Appendicitis	T.B.enterocolitis	Crohn's disease,	Total
Number of Cases	50	14	7	5	3	79/131

Table 5

The Pathological Causes of Surgical Pneumoperitoneum and Anatomical relation.

	Gastro-duodenal	Small bowel	Large bowel	Appendix	Total
Inflammatory	50	7	15	7	79 (60.3%)
Traumatic	2	11	9	0	22 (16.8%)
Post-operative Leak	3	2	4	0	9 (6.9%)
Neoplastic	0	3	5	0	8 (6.1%)
Vascular	0	5	8	0	13 (9.9%)
Total	55	28	41	7	131 (100%)

Our study revealed that Gastro-duodenal area was the most common site of perforation, (55/131) 42% of all surgical pneumoperitoneum cases, (55/450) 12% of all emergency laparotomies, therefore 31.3%, 21.4% of visceral perforations were detected in the large and small bowel respectively. Acute appendicitis is a rare cause of intraabdominal air leak, with a reported incidence 0–7% [9], it was discovered in 5.3% of pneumoperitoneum cases in this entire study.

The inflammatory conditions still constitute the main source/background of pneumoperitoneum, 79 cases out of 131 (60.3%) of visceral perforations were due to inflammatory conditions. The most common reported cause of surgical pneumoperitoneum in the literatures is perforated Gastro-duodenal ulcer [7,8], that was clearly confirmed in this study, that gastro-duodenitis with perforation from peptic ulcer disease was also the most common cause of the inflammatory-related perforations (50 cases). The other included inflammatory conditions were 14 cases with diverticulitis (12 in the large bowel, 2 in the ileum), perforated acute appendicitis in 7 cases, T.B. enterocolitis and Crohn's disease, which were less frequently found in the study 5,3 cases respectively. [Table 4](#).

Neoplasia causes perforation in 8/131 (6%) in large and small bowel, either by direct invasion or rupture of the proximal bowel due to obstruction.

Trauma was documented in 22/131 (16.8%), 8 cases of them were caused by direct external trauma, while 14 cases were due to iatrogenic injury, as unintended bowel perforation during surgical, gynecological, or urological operations, as well as post- endoscopic procedures (ERCP, Colonoscopy, PEG insertion).

A post-operative leak was also seen in 9 cases (6.9%), most of them were from anastomosis of bowel or following repair of perforation of the stomach or small bowel.

Ischemia and vasculopathy were the underlying causes of bowel rupture in 13/131 patients (9.9%), Thromboembolic in 10 cases while 3 cases of strangulated hernia (2 para-umbilical, one ventral hernia) were the causative agents of that entire ischemia with the consequent perforation. [Table 5](#)

The other category of pneumoperitoneum, which was not included in the study is the Non- surgical or spontaneous pneumoperitoneum, it is uncommon entity, but well-known and repeatedly described, It is usually an

incidental radiological finding rather than clinical manifestation [10], appreciation of these cases helps to avoid unnecessary surgery [11].

It results from thoracic, abdominal and gynecological causes, any cause of increased intra-thoracic pressure can produce pneumoperitoneum, barotrauma is the main thoracic cause. In females there is a natural communication between the fallopian tubes and peritoneum, which may predispose to non- surgical pneumoperitoneum. Pelvic examination, vaginal insufflation or douching are good examples of the gynecological causes of non- surgical or spontaneous pneumoperitoneum.

In the abdomen, air may retain normally after surgeries for longer periods from 3–6 days, up to 4 weeks, while in laparoscopy the current preferred gas in insufflation is Carbon dioxide, which is rapidly absorbed, than room air entered during laparotomy, existence of gas post laparoscopy is smaller and shorter. Intra-peritoneal catheters for dialysis or open drains, seemed to be reliable abdominal causes of non-surgical or spontaneous pneumoperitoneum. Mularski et al., Tiwary et al., Kadkodaie et al. and Cecka et al., had considered the air leak following the iatrogenic endoscopic procedures as abdominal non-surgical pneumoperitoneum, which is probably due to excessive insufflation, excessive electrocautery and incautious papillotomy in ERCP, but in fact these entire perforations are often result in peritonitis and necessitate surgery, it is advisable to include them with surgical pneumoperitoneum, 4 cases in our study were explored for that complication after endoscopic procedures (ERCP, Colonoscopy, PEG insertion).

A detailed history should be obtained, regarding symptoms, history of trauma, previous medical illness, recent abdominal operation, peritoneal dialysis, endoscopy and medications as anticoagulant. Thorough examination generally and locally should be exercised before asking for investigations.

Plain x-ray film in erect position may be enough to diagnose pneumoperitoneum, it shows air under diaphragm in chest view, or in superiorly dependent location on abdominal radiograph, Plain x-ray imaging is simple, low cost, non-invasive and efficient tool of investigation.

C.T. studies can verify the presence of air and fluids, point to the area of perforation, assess the wall thickening, mucosal integrity, and also view fat stranding, pneumatosis

intestinalis, gas in portal venous system and other clues. C.T. Scan is a sensitive method of imaging, it identifies the cause and site of acute abdomen. Modern technology with multi-detector C.T is highly accurate and more sensitive in predicting the site of perforation [12,13].

The cause of pneumoperitoneum and signs of peritonitis determine the mode of treatment, when pneumoperitoneum is coupled with clinical picture of acute abdomen, it needs prompt surgical intervention, to eliminate the enteric contamination of the abdominal cavity and to deal with the resultant perforation, therefore pneumoperitoneum with minimal symptoms and no signs of peritonitis justifies observation and supportive care as conservative measures.

5. Conclusion

Pneumoperitoneum is abnormal collection of air within the peritoneal cavity, it remains as a reliable sign of visceral rupture [14], it frequently indicates bowel injury or disease [15], hence it is called surgical pneumoperitoneum. Perforations are commonly found in gastro-duodenal area, the inflammatory conditions are responsible for the vast majority of cases. Presence of air with intact bowel is called non-surgical or spontaneous pneumoperitoneum, that results from thoracic, abdominal and gynecological causes.

Detailed history and careful examination with simple radiograph can discern between surgical pneumoperitoneum which needs urgent operation, and non-surgical, which has to be approached conservatively.

References

- [1] Mularski RA, Sippel JM, Osborne ML. Pneumoperitoneum: A review of nonsurgical causes. *Critical Care Medicine* July 2000;28(7):2638–44.
- [2] Tiwary S, Agarwal A, Kumar S, Khanna R, Khanna A. Idiopathic Massive Pneumoperitoneum. *The Internet Journal of Surgery* 2005;8(2).
- [3] Pitiakoudis M, Zeros P, Oikonomou A, Kirmanidis M, Kouklakis G, Simopoulos C. Spontaneous idiopathic pneumoperitoneum presenting as an acute abdomen: a case report. *Journal of Medical Case Reports* December 2011;5:86.
- [4] Khan AN; Chief Editor: Eugene C Lin, MD more... Pneumoperitoneum Imaging. *MedScape* Apr 07, 2014, as Viewed in Google Scholar.
- [5] Williams NM, Watkin DF. Spontaneous pneumoperitoneum and other nonsurgical causes of intraperitoneal free gas. *Postgrad Med J* 1997;73:531–7, <http://dx.doi.org/10.1136/pgmj.73.863.531>.
- [6] Kadhodaie HR, Vaziri M. Asymptomatic Spontaneous Pneumoperitoneum. *Shiraz E Medical Journal* October 2008;9(4). *SIGNA VITAE*; 2014 9.
- [7] Mularski RA, Ciccolo ML, Rappaport WD. Nonsurgical causes of pneumoperitoneum. *West J Med* 1999;170:41–6.
- [8] Matar ZS. ACUTE ABDOMEN WITH PNEUMOPERITONEUM. *J Family Community Med* 2004 May-Aug;11(2):71–2.
- [9] Campos Canelas AL, Fernandez HM, Crociati Meguins L, Silva Barros S, Crociati Meguins EM, Ishak G, Rodrigues De Moraes LA. Pneumoperitoneum in association with perforated appendicitis in a Brazilian Amazon woman. *Case report. G Chir* 2010 Mar;31(3):80–2.
- [10] Čečka F, Sotona O, Šubrt Z. How to distinguish between surgical and non-surgical pneumoperitoneum? *SIGNA VITAE* 2014;9(1):9–15.
- [11] Karaman A, Demirbilek S, Akin M, Gürnlüoğlu K, Irşi C. Does pneumoperitoneum always require laparotomy? Report of six cases and review of the literature. *Pediatr Surg Int* 2005;21:819–24.
- [12] Hainaux B, Agneessens E, Bertinotti R, De Maertelaer V, Rubesova E, Capelluto E, Moschopoulos C. Accuracy of MDCT in predicting site of gastrointestinal tract perforation. *AJR Am J Roentgenol* 2006;187:1179–83.
- [13] Oguro S, Funabiki T, Hosoda K, Inoue Y, Yamane T, Sato M, Kitano M, Jinzaki M. 64-Slice multidetector computed tomography evaluation of gastrointestinal tract perforation site: detectability of direct findings in upper and lower GI tract. *Eur Radiol* 2010;20:1396–403.
- [14] Winek TG, Mosely HS, Grout G, Luallin D. Pneumoperitoneum and Its Association With Ruptured Abdominal. *Viscus Arch-Surg* 1988;123(6):709–12, <http://dx.doi.org/10.1001/archsurg.1988.01400300051008>.
- [15] Woelfel GF, Hansbrough JF. Spontaneous Bacterial Peritonitis and Pneumoperitoneum A False Surgical Emergency. *MD JAMA* 1983;249(7):921–2, <http://dx.doi.org/10.1001/jama.1983.03330310051026>.