The Diagnostic Use of Artificial Pneumoperitoneum*

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Artificial pneumoperitoneum is a procedure with which doctors are familiar, particularly in respect to its therapeutic application in pulmonary tuberculosis and chronic diffuse pulmonary emphysema. Diagnostic use of the procedure in lesions of or near the diaphragm is well known to chest physicians and surgeons, yet some general practitioners, surgeons and radiologists have remained hesitant to utilize pneumoperitoneum as a part of their diagnostic armamentarium. This is no doubt due to relative unfamiliarity with the technic of the procedure and overemphasis in the medical literature of the dangers, contraindications, and complications of induced pneumoperitoneum. As chest physicians for whom the induction of pneumoperitoneum holds little fear, we are in a position to acquaint our fellow practitioners in other specialties with the relative benignancy of the procedure as well as its wide applicability in a variety of clinical situations. It is our aim to review herein briefly some of these applications.

Jacobaeus,1 in 1913, first suggested the use of pneumoperitoneum to provide contrast for roentgen visualization of the abdominal viscera, and Orndoff,2 in 1919, reported his experience with this method in more than 100 cases with lesions of the upper abdominal viscera. It has been used with success in suspected subdiaphragmatic abscess. Sante,3 four years later, reported the case of a young man with perinephric abscess complicated in the postoperative period by right pleural empyema, in whom hiccup and abdominal pain appeared. The right diaphragm was seen to be elevated on chest x-ray inspection and a strong clinical suspicion of right subdiaphragmatic abscess was entertained. Artificial pneumoperitoneum was induced, after which roentgenograms revealed a completely free space, containing air, between the liver and the right diaphragm. Thus, this procedure satisfactorily ruled out subdiaphragmatic abscess, abdominal exploration was avoided, and right thoracotomy was performed for the empyema, resulting in cure.

In this same paper, Sante advocated utilizing pneumoperitoneum in distinguishing cardiospasm from malignancy of the lower esophagus or cardiac portion of the stomach. He stated that, in cardiospasm, esophageal constriction occurs at the level of the diaphragm with a dilated sac above, and no involvement of the region between the diaphragm and cardiac orifice of the stomach, this being well seen with the aid of pneumoperitoneum. In carcinoma of the esophagus or cardiac stomach a constriction and irregularity may be seen with barium meal, but the extent of the

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lesion may not be appreciated until pneumoperitoneum is also utilized. This often demonstrates a mass in the area between the diaphragm and the cardiac stomach, serving to differentiate malignancy from a benign lesion.

Thirty years later, Meneghini and De Marchi again advocated a barium meal and pneumoperitoneum combined in the study of lesions in this region. They gave pneumoperitoneum of 1000 to 1500 cc. of oxygen, and immediately had the patient ingest semi-dense barium, fluoroscopy then being performed in various positions. In their report of seven cases, the authors felt that this combination is superior to either a barium swallow

FIGURE 1: Pneumo-roentgenogram of the pelvis of a 30 year old woman who is receiving pneumoperitoneum therapy for pulmonary tuberculosis, and who has had vague right lower quadrant pain. Pelvic examination was unsatisfactory because of the presence of the pneumoperitoneum. This film shows the uterus to be normal in size and shape, and both fallopian tubes and the left ovary to be normal. The right ovary is slightly enlarged, and may represent a cystic condition. In view of the normal size of the fallopian tubes it was felt that tuberculous salpingitis was ruled out, so that pelvic surgery could be safely deferred. We feel that this diagnostic study saved the patient unnecessary laparotomy.
or pneumoperitoneum alone, especially in the study of malignant tumors of the cardia. They state it permits evaluation of the presence and degree of extension of the lesion into surrounding structures, as well as the existence of adhesions between the stomach and diaphragm. This information aids in assessing operability and deciding upon operative approach.

Pneumoperitoneum has been recommended as an auxiliary method in the diagnosis of early exudative tuberculous peritonitis by Deloff. He points out that quantities of peritoneal fluid of less than 1000 cc. cannot be definitely detected by ordinary clinical and radiographic means, but that, after pneumoperitoneum of 500 to 600 cc. of air, as little as 300 cc. of fluid can be detected by gurgling during insufflation of gas, succussion splash, and x-ray inspection showing a fluid level. We have not used pneumoperitoneum in this way, however, since it seems that paracentesis abdominis will usually provide an answer.

Visualization of the pelvic viscera, using carbon dioxide as the contrast medium, was first described by Alvarez in 1921, and several papers have since appeared on this subject. The procedure was utilized by Stein in the demonstration of tubal pregnancy, and its value has again been stressed by Gershon-Cohen and Hermel as an aid in the diagnosis of subserosal uterine tumors, bicornate or double uterus, and in the visualization of ovarian or tubal masses which may be too small to be disclosed by bimanual pelvic examination. They performed pelvic x-ray examination upon 30 female tuberculosis patients receiving pneumoperitoneum therapy, and studied the pelvic organs thus visualized, publishing their findings in 1952 and 1953 with many beautifully clear reproductions of these roentgenograms. They found normal pelvic organs on such films to have the following dimensions: fallopian tubes—3 to 6 mm. thick; uterus—5 to 7 cm. wide and 3 to 5 cm. thick; and ovaries—2 to 4 cm. long and 1.5 to 3 cm. thick.

With the bladder and rectum empty, pneumoperitoneum of 500 to 1000 cc. is instituted by the transabdominal or transvaginal route, as for the Rubin test of tubal patency. The patient is placed prone on the x-ray table with two pillows beneath the thighs, and an air pillow beneath the epigastrium, so the pelvis is elevated with the patient in a modified knee-chest position. The x-ray beam is angled through the pelvic canal axially, and three films taken directed at 10, 20, and 35 degrees cephalad. The Potter-Bucky diaphragm is used, preferably with a 16:1 grid ratio. Average roentgenographic factors are: 80 KV, 300 MAS, 40 inch target-film distance, and par speed intensifying screens. They feel the procedure is contraindicated in ruptured tubal pregnancy, and do not use the transuterine route during pregnancy, vaginal bleeding, acute cervicitis, or pelvic inflammatory disease.

Kunstadter and his associates, in 1953, reported the application of pelvic pneumoperitoneum in the diagnosis of sex-endocrine disturbances. They studied 17 patients, whose ages varied from 11 weeks to 23 years, by means of pelvic x-ray inspection after the introduction of 500 cc. of carbon dioxide transabdominally. Among this group were seven cases of
ovarian agenesis, one of hypopituitarism, two of pituitary hypo-ovarianism, one of cystic ovary, two of constitutional sexual precocity, and four of pseudohermaphroditism. One of the latter was an 11 week old infant, in whom the procedure was performed without untoward effect, and clearly demonstrated female pelvic organs. The authors suggest that pelvic pneumoperitoneum may aid in diagnosis when clinical and laboratory study is inconclusive and early diagnosis is important to plan future management, thus avoiding laparotomy.

Carman and Fineman,11 in 1924, reported the use of pneumoperitoneum as an aid in the diagnosis of diaphragmatic hernia. Bockus,12 in his textbook on gastro-enterology, does not mention pneumoperitoneum as an auxiliary diagnostic method in his extensive discussion of diaphragmatic hernia. Eventration of the diaphragm, hiatus (esophageal) hernia, and large (non-hiatus) hernia can usually be diagnosed satisfactorily by the usual chest x-ray film, barium meal, barium enema, and characteristic history, with no need for pneumoperitoneum.

More recently, however, Stewart13 described three patients with para-sternal omental hernia, emphasizing the use of pneumoperitoneum as an accessory diagnostic aid. These hernias present themselves roentgenographically as a density in either cardiophrenic angle on the chest film,

![FIGURE 2A](image_url)

**FIGURE 2A**

*Figure 2A:* From a postero-anterior chest x-ray film of a 45 year old woman with chronic cough of five years duration, the film showing a homogeneous density at the right cardiophrenic angle.—*Figure 2B:* Right lateral view of same patient showing that the density is anteriorly overlying the heart shadow, in the region of the right middle lobe.—*Figure 2C:* Right bronchogram seen on lateral view in same patient after instillation of lipiodol, demonstrating bronchiectasis and atelectasis of the right middle lobe.—*Figure 2D:* Postero-anterior chest x-ray film of same patient after pneumoperitoneum had been established. This shows that air has entered the area of the cardiophrenic angle density, demonstrating a fairly large hernia of the foramen of Morgagni.—*Figure 2E:* Right lateral view of this patient with pneumoperitoneum present, showing the air-filled hernia sac lying anteriorly. Exploratory thoracotomy on the right was then performed, an atelectatic right middle lobe was removed which was found to contain extensive bronchiectasis, and the diaphragmatic hernia of the space of Morgagni was repaired.
and must be differentiated from benign or malignant neoplasms (mediastinal or pulmonary), aberrant thyroid, and embolic, inflammatory, or atelectatic lung lesions. In one patient, pneumoperitoneum resulted in the appearance of air in the hernial sac on x-ray film. He suggests that pneumoperitoneum will have its greatest usefulness in cases in which barium enema studies fail to demonstrate cephalad and anterior displacement of the transverse colon.

Rowles and Crenshaw,14 in 1958, described nine thoroughly studied patients with diaphragmatic herniation through the space of Morgagni, six of whom were successfully repaired at thoracotomy. In one of them, upper gastro-intestinal x-ray films, barium enema, and x-ray film of the chest with pneumothorax and pneumoperitoneum were all negative. However, in two, in whom operation was not done, pneumoperitoneum demonstrated clearly the presence of air in the hernial sac, providing reassurance that the lesion was of benign nature.

As a rule, the diagnosis of tumor of the diaphragm can be strongly suspected from the appearance of the chest x-ray film, and the chest surgeon is led to promptly explore the chest surgically. Occasionally the picture may be suggestive of diaphragmatic hernia or elevation of the diaphragm from an intra-abdominal disorder. Induction of pneumoperitoneum will tend to rule out these latter conditions, and may outline quite clearly the size and density of the lesion and its intimate connection with the diaphragm, making preoperative diagnosis more definite.

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**FIGURE 3A**

*Figure 3A:* From a postero-anterior chest x-ray film of a 35 year old woman in whom a survey film revealed a rounded density in the left diaphragm. She had no symptoms relating to the chest or the gastro-intestinal system.---*Figure 3B:* Left lateral view taken at the same time, showing the density to be lobulated and situated anteriorly. Fluoroscopy of this patient after pneumoperitoneum revealed the density to appear solid and containing no air (no film available). Barium meal was normal. Left thoracotomy was done and a large, multiloculated, fluid filled cyst was found to be attached to the left diaphragm. This was removed, and she made an uneventful recovery.
SUMMARY
1. Artificial pneumoperitoneum may be applied as a diagnostic aid in a variety of clinical situations, as in:
   a) Suspected subdiaphragmatic abscess.
   b) Lesions of the cardiac portion of the stomach, when the pneumoperitoneum is combined with a barium meal.
   c) The detection of ascites, when the amount of fluid is small.
   d) The study of pelvic organs of adult females.
   e) The study of sex-endocrine disorders.
   f) The study of patients whose chest x-ray films show densities lying in the lower thorax in contiguity to the diaphragm.

2. As chest physicians, we are familiar with the technic of artificial pneumoperitoneum and thus may be of aid to our fellow practitioners in other specialties in encouraging the use of this helpful procedure.

RESUMEN
1. El neumoperitoneo artificial puede usarse como recurso diagnóstico en una serie de situaciones clínicas tales como:
   a) Sospecha de absceso subfrénico,
   b) Lesiones de la porción cardial del estómago cuando el neumoperitoneo es combinado con una comida de bario.
   c) El descubrimiento de ascitis cuando la cantidad de líquido es pequeña.
   d) El estudio de los órganos pélvicos en las mujeres adultas.
   e) El estudio de los trastornos sexuales endocrinos.
   f) El estudio de los enfermos cuyas radiografías muestran opacidades en el tórax cerca del diafragma.

2. Como especialistas del tórax, estamos familiarizados con la técnica del neumoperitoneo artificial y así podemos ayudar a nuestros colegas, médicos de otras especialidades para alentar el uso de este procedimiento útil.

RESUME
1. Le pneumopéritoine artificiel peut être utilisé dans plusieurs cas cliniques dans un but diagnostique; il en est ainsi:
   a) lorsqu'on suspecte un abcès sous-diaphragmatique;
   b) pour des lésions gastriques localisées au cardia; il y a lieu alors de combiner le pneumopéritoine avec le repas baryté;
   c) pour la découverte d'ascite, lorsque la quantité de liquide est faible;
   d) pour l'étude des organes pelviens chez les femmes adultes;
   e) pour l'étude des troubles des glandes endocrines génitales;
   f) pour l'étude des malades chez lesquels les radiographies montrent des ombres de la partie inférieure du thorax, qui semblent contiguës du diaphragme.

2. Les auteurs font remarquer que les médecins spécialisés en affections thoraciques qui sont par conséquent familiarisés avec la technique du pneumopéritoine artificiel, peuvent aider leurs collègues des autres spécialités en les engageant à utiliser ce précieux procédé.
DIAGNOSTIC USE OF ARTIFICIAL PNEUMO

REFERENCES


