Review Article

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Incidental historiographic faux pas of venous air embolism in laparoscopy, reviewed critically: humanum est errare

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ABSTRACT

Historiographic antecedents about ambient air (AA) for embolism in operative laparoscopy (OL) are critically reviewed to decipher its representation; for its immense clinical and economic implications. Rumours of air embolism (AE) in beginning of twentieth century were based on rampant use of air tamponade in abdomen and chest for tuberculosis in absence of definitive treatment. News of AE in head, neck, dental and other open surgeries also compounded negative image of air for embolism. Resultant antiair heresy continued in medical press globally bereft of actual knowledge of etiopathophysiology of AE or gas embolism and biomechanics of pneumoperitoneum (PP). This incidental blemish was extended to OL also with divergent etiopathophysiology even when gas used was or is other than air, e.g., CO₂, N₂O, or O₂, etc in PP and none of them are similar to each other in physical or chemical characters.

Keywords: Ambient air, Historical faux pas, Gas or air embolism, Laparoscopy, Pneumoperitoneum

INTRODUCTION

This dissertation critically reviews historiographic anecdotes about air embolism (AE) or gas embolism (GE) in operative laparoscopy (OL) started in early twentieth century, when transportation, communication, scientific understanding etiopathophysiology biophysics and pneumoperitoneum (PP) in OL and academic milieu were all in nascent stages.1 In such dark era of poorly understood scientific subject of GE or AE for its pathological moribund consequences; historical antecedents of ambient air (AA) for GE is essential because of its immense scientific, clinical and economic utility of AA in OL in global perspective. It should be understood that gas (One of the four types of matter) is subdivided into four types which is vast subject in physics. Air, O_2 , CO_2 , He, N_2O , is not identical or synonymous to gas or to each other in chemical or physical nature anyway. Physics of gas is addressed briefly elsewhere with mechanism and myth of AE or GE in OL.

Subliminal historiographic concerns and confusions

Surgeons had been working on minimal access surgery from beginning of twentieth century and trying to develop techniques to reduce iatrogenic surgical trauma. Scientific knowledge was in its nascent stages and medical profession was just evolving. Nezhat observed as late as in 2005, "...Ironically, the same conditions that give rise to complications for today's surgeons were affecting our early 20th century counterparts too: lack of adequate training or equipment, inexperience, and

improper technique or instrumentation. As well, problems with limited visualization, inability to detect or stop intraoperative haemorrhaging, deaths caused by unpredictable
insufflation complications, burns caused by electrocautery, bowel perforations, and injuries to major blood
vessels still served to scare off would-be practitioners
from attempting endoscopic techniques in the first place
or investing in its further development". He continued,
"...ultimately, this translated into safer laparoscopy,
which helped reduce instances of bowel perforations and
retroperitoneal vascular injuries." He enumerated
laparoscopic complications for surgeons from 1920s to
1960s until 2005 sans concern for AE or GE.

Semm lamented. "General surgeons condemned gynecologists when a complication occurred (e.g., puncture of a large blood vessel, high frequency current burning of bowel, ureter, etc)."4 He also discussed other complications viz. burns from hot ends of light sources, burns from high frequency current to skin, trocar injuries to bowels and blood vessels, visual and light issues. He also deliberated on intraoperative hypothermia at length, without AE. He stated without whimper of AE on change of air to CO₂, "Semm replaced the old air insufflation system and published this in 1965." He recalled, "I spent long, long hours working with my drill, hammer, and screwdriver. Every part, every detail of the insufflation device was designed, constructed, and finally built by myself."5,6 Semm's father and brother owned medical instrument company.^{7,8} Reddick recounted major vascular, trocar related, intestinal, and common bile duct injuries without mention of AE or GE.9

Beginning of defamation of air in laparoscopy

Poor impression of air for embolism started in early part of Twentieth Century due to scourge of tuberculosis that had no medicinal treatment those days. ¹⁰ Litynski stated about Jacobaeus (1879-1937), 'We know that before he began his work with 'laparothorascopy," he was aware of artificial pneumothorax, and pneumoperitoneum in the treatment of peritonitis tuberculosa.' ¹¹ Empirical use of air tamponade in abdomen and chest caused deaths from AE paving way for fear of air. ¹²⁻¹⁴ Reports of death also appeared in open surgery, e.g., faciocranial, neurosurgical operations and dental surgery for AE especially in sitting position; compounding fears further.

Chan and Yang (1969) stated, "Air embolism is a dreaded complication in surgical, therapeutic and diagnostic procedures..." But their paper is titled as, "Survey of Literature Related to the problems of Gas Embolism in human body." Apparently, they make no distinction between air and gas. They went on detailing host of procedures and pointed out scientific apathy to inspire research, "No apparent effort has been made on the study of their dynamic behaviour..." yet apathy persists for about five decades. These reports, irrelevant to laparoscopy laid the foundation for 'antiair' views. It was so deeply encrypted in the psyche of medical faculty,

"Even a whimper of embolism would instantly lead to revolt and consternation against air." Development of OL confronted such established antiair tirade in twentieth century with divergent etiopathology; holding it at bay for almost entire twentieth century and world lost almost one fruitful century of its surgical advantage.

Laparoscopy attempts in first decade of twentieth century

In 1901, three persons worked simultaneously but independently on same problem. Vecchio et al observed, "The idea that formed the framework for laparoscopic surgery was initially reported in the first years of this century by a Russian gynaecologist, Dimitri Ott, a German surgeon, George Kelling and a Swedish surgeon, Hans Christian Jacobaeus..." ¹⁵

Kelling performed closer to modern laparoscopy on dog in 1901. 16-18 He used Nitze cystoscope and filtered AA by cotton through Fiedler needle calling it koelioskopie. Ten years later he reported his experience in 45 humans. 15,17 Also in 1901, Ott inspected abdomen of pregnant woman inserting speculum through vagina. 19 Eight years later he inspected abdomen by minilaparotomy with speculum calling it ventroscopy.²⁰ "In 1903, Ott reported on more than 606 operations carried out per vaginum." observed Litvnski.²¹ Jacobaeus published his report "laparothorakoskopie" in 1901, without PP using posture change for visibility and inspected abdominal and thoracic viscera.²² He reported in 1911 on 72 patients his experience of 115 procedures.^{23,24} Bernheim in USA reported two cases of Organoscopy again in 1911.²⁵ None of them had problem of AE. WW I hampered further researches and development in OL.

Post WW I nascent era of scientific stagnation

Apparently words, AE or GE was, is used interchangeably even when CO2 or some other gas is used.^{2,12,18,26-28} One publication stated, "the switch to Oxygen may have been prompted by Orndoff's experience with losing a few patients due to air embolism associated with carbon dioxide insufflation. Orndoff did apparently have a few deaths from air embolism using carbon dioxide. In 1921 he reported on these adverse outcomes."² Orndoff apparently fortified myth of AE in OL further by pontificating CO₂ while demeaning AA. He also used AA, for instance, he changed from using regular atmospheric air to the more pure (but less stable) element of oxygen.² Same publication contrastingly states, 'Nadeau and Kampmeirer did one of the best reviews of literature that could be found from the 1920s. In 1925, they compiled a meticulous meta-analysis of the entire peritoneoscopy literature. These two authors... focused on the fact that they found it strange that something so useful as abdominoscopy would be so rarely used," In the end, the method was said to be one which "has hardly met with a clinical mishap which could serve as a hindrance to its acceptance."2 It clearly shows, AA was used in OL those days usefully and free from complications, yet blaming air for embolism instead of O₂ or CO₂, is strange.

Walker (1943),²⁹ Ruddock (1949),³⁰ Handley and Nurick (1956),³¹ Morison and Riggs (1974),³² Udwadia (1986),³³ had used AA with impunity. Cushieri warns against air in laparoscopy,³⁴ but vouches for surgeon factor.²⁶ Zhang et al used CO₂ in 2005 but innocently misconstrue *AE* in their text like Orndoff.³⁵

Laparoscopy and invention of CO2 insufflator

AA was used in PP by manually operated crude devices, e.g., baumanometer cuff, syringes, rubber double balloon pump, modified cycle air pump, Bonnet device of Palmer and similar devices with no control on speed or amount of AA used in PP and IAP. 4.6.7.30 Goetze invented insufflator in 1921 and Zollikofer introduced CO₂ in 1924.2 Semm described internists using a cylinder 15cm in diameter and 20cm long with manually operated piston for PP. 4.6 He devised CO₂ insufflator in 1955 for insufflation of fallopian tubes and presented at Second World Congress on Sterility and Fertility in Italy. 36 He used it in PP later and presented it to Melvin Cohen of Chicago in 1967. 6

In switch over to CO₂ insufflator, Semm apparently served two major interests. 1) Hide bad names of air and laparoscopy in midtwentieth century.²⁻⁴,1²,2⁷,2⁸,3⁷ 2) Commercial interests.⁵⁻⁸ Semm himself misconstrued AE using CO₂ that defines the panic for prevalent heresy.³⁷ Cottin et al and Bruyere et al had used CO₂ but strangely their publications were captioned, "Gas embolism during laparoscopy: a report of seven cases in patients with previous abdominal surgical history "and "Gas embolism during radical nephrectomy by retroperitoneal laparoscopy respectively.^{27,28} The CO₂ escapes again her guilt.

Continued use and abuse of air in later twentieth century laparoscopy

Despite induction of CO₂ by Zollikofer (1924) and popularity of CO₂ insufflator by Semm in 1965, use of air in OL continued past midtwentieth century. 21,29-33 Its use continues till date secretively, reported by colleagues verbally to Sudrania. Shift from air to CO₂ might be for (a) Infamy tagged to air. 12,27,28 (b) Easy availability of CO₂ in affluent societies (c) Poor image of laparoscopy.²⁻ ^{4,37} (d) Agoraphobia in gynecologists for fear of surgeons who as Semm puts, "The General surgeons condemned gynecologists when a complication occurred."4 This was further ratified by Nezhat, "Indeed, general surgeons in particular were appalled at the idea of a gynaecologist teaching real surgeons how to operate."³ (e) Nezhat continues, "1961 proved to be a critical moment in Germany, as the laparoscopy experienced a great fall from grace when the German Federal medical institutions actually enacted a total ban on its use, proclaiming it to be a prohibitively hazardous procedure."³ (f) Prevailing antiair medical conundrum.

Litynski quotes, "In the late 1950s, internists were still using atmospheric air injected via a needle to insufflate the stomach cavity (sic). ... Frangenheim... decided to build an insufflator... a built-in safety valve avoids any insufflation with a pressure of over 250mmHg. Despite such precautions, Frangenheim recommended that the gas pressure in the stomach cavity (sic) ... was not to exceed 30-40 mmHg...". In German medical press of the time we find numerous articles promoting laparoscopy."²¹ This shows (a) Air was being used for PP even in 1950s and 60s; shifting to CO₂ for antiair tirade. Semm was gynaecologist and engineer also with family owned engineering workshop, viz. Wisap.8 (b) Use of 40mm or even >250mm of Hg IAP was common, also ratified by Modlin et al in 2010.21,38 (c) Technology was in infancy stage, e.g. atmospheric air injected via a needle.² (d) Despite bad reputation, laparoscopy did have recognition in Germany among surgeons.^{21,39} (e) IAP of 40 to 250 mm Hg reflects on scanty knowledge of etiopathology and biomechanics of IAP and dire consequences of AE or GE.

In midtwentieth century gynecologists and urologists used laparoscopy but surgeons scoffed at.^{39,40} Its reputation was so bad that they used noms de plume, e.g. Semm used pelviscopy.^{2-4,6,37} Mettler recalls, "The term pelviscopy was selected by Kurt Semm in 1970 to differentiate between the gynecological laparoscopic procedure and that of the internists who performed laparoscopy with upper abdominal screening and liver biopsy."³⁷

Litynski quotes Semm, "You have to remember, I had clinical experience with tubal insufflation, and at that time deaths due to gas insufflation into tubes had been reported- air emboli. I was afraid that a patient in the Internal Medicine Clinic would die of air embolism and my apparatus would be blamed... One dead patient and I would be finished. Forever." Semm seemed apparently scared of antiair tirade for emboli in medical press. It is his notable submission in light of contemporaries with no problems using AA. Significantly, Kalk published in 1939, one of the largest series of laparoscopic surgery of 2000 procedures without mortality when others had mortality of 2-5%.

Ruddock reported in 1949, "After local anesthetization, the pneumoperitoneum needle is inserted and the abdomen tightly distended with ordinary unfiltered air pumped in with a baumanometer bulb... to keep the cavity distended with air during the entire procedure in order to insure good visualization." Phrases like, abdomen tightly distended, ordinary unfiltered air, keep the cavity distended with air during the entire procedure, indicate little idea of effects of tight distension and biomechanics of IAP on embolism or infection from unfiltered air. Ruddock stated three mortalities and

specified, "No cases of air embolism have been noted." Kalk and Ruddock were so idolised, "Before the Second World War there were two centers of laparoscopy in the world: Germany (Kalk) and the United States (Ruddock)."

In a high tension progressive PP technique practiced by Moreno and Willis preoperatively in large ventral hernias for abdominal viscera losing right of domicile in peritoneal cavity; did not report AE using AA. 45,46 Moreno altogether reported his technique in 700 cases. 47 This was fully discussed in Suvretta II-meeting, March 8-14, 1998 in Switzerland published by Schumpelick and Kingsnorth. 48

Communication with Kurt Semm

2003, Sudrania (Personal On 25 February communication) wrote to Semm to enquire about problem of air in OL since he designed CO2 insufflator replacing use of air. Relevant extract from the letter reads, "When you developed and replaced your air insufflator in 1963 with CO2 insufflator; were there any problems with the use of air in pneumoperitoneum that led you to replace it with CO2. I have been using air in operative laparoscopic surgery for past quite a few years with a very gratifying result. My personal feeling is that the use of air has been better with the current air insufflators."

Semm being gravely ill, the letter was replied by his colleague, dated 17th April 2003/DR. Here is a relevant extract; "...You wish to enquire about the use of air in operative laparoscopy. Air was abandoned and replaced by CO₂ because air embolisms occurred. For this reason, author think the use of air in operative laparoscopy should not be reintroduced." Here, author think hints at premonition like argumentum ad populum. Embolism occurs still with CO₂, but without flutters.^{27,28}

Practical implications of this historical faux pas of air embolism

It diverted attention from real issues like Surgeon factor and biomechanics and pathophysiology of mechanism of AE or GE and its dire consequences by blame and heresy of air or gas for embolism.²⁶ AA in OL is medically useful, freely, ubiquitously available, hassle free and economic by eliminating cylinders. It is scientific, better in cancer Vis a Vis CO2 that encourages port metastasis and recurrence at anastomotic site. 40,49 Postoperatively patient is euthermic, as AA causes less cryogenic effects Vis a Vis compressed gases.⁴ Postoperative rigor appears for lack of intraoperative temperature control than other reasons, e.g. pyrogens in intravenous infusions. Cryogenic effect of gas is mostly due to Joule Thomson Effect; less for inherent property of gas. Acidosis due to CO₂ makes air safer in old fragile patients, cirrhotics, cardiopulmonary cripples, pregnancy, renal deficiency, immunocompromised and longer OL procedures.⁴⁹ AA

can be useful in remote corners of world including battle fields, camp surgeries, weaker economies, etc, where OL may be indispensable, yet denied for want of CO₂.

Sudrania faced sudden stoppage of CO₂ supply for indefinite period and had to stop OL. Perusing Palmer during WW II, Litynski quotes, "Palmer needed... transportation...to look outside Paris for supplies.... Gasoline was reserved for public transportation and use by the German forces. Palmer had to pack the empty sparkets onto a bike and ride several miles into the countryside, where he was able to refill them." Lawful use of AA may save posterity such travails.

Mechanism of surgical smoke and myth of air embolism

Gas used in OL do not appear to be virgin in ensuing GE due to formation of surgical smoke (SS).^{51,52} During heat of OL, there is always some leak of AA beside cannulae in ports, polluting the PP gas, e.g. CO₂, beyond control. Exact composition of SS formed in OL at the given moment is polemic that forms embolus irrespective of type of gas used in PP. Exact mechanism, role played by gases in PP and complications of AE or GE are still highly contended issues.^{53,54} These have been discussed elsewhere.

CONCLUSION

This review attempts to decode incidental historiographic Faux Pas of AE or GE in OL oblivious of its scientific impact; misrepresented due to poor knowledge of pathophysiology and biomechanical events of AE, GE in early twentieth century. Ever since, when gases used were O₂, CO₂, N₂O etc., blame was, is put on AA till date. This historical mishap ostensibly added to scientific confusion about use of AA in OL with immense loss of scientific progress during most of twentieth century, despite AA in OL being patient friendly and useful. It had colossal economic potentials for health delivery system especially in difficult situations.

This case of AA for embolism is an apparent 'irrelevant conclusion' or ignoratio elenchi deduced by argumentum ad ignorantium. Its redressal is just and overdue in greater interests of scientific accuracy and proper delivery of human health services globally. It economizes by eliminating cylinders.

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