SCIENTIFIC PAPER

Shakespeare's View of the Laparoscopic Pneumoperitoneum

Douglas E. Ott, MD, MBA

ABSTRACT

Background: The laparoscopic pneumoperitoneum is created and maintained in a physiologically homeostatic potential space that is 37-degrees Centigrade (°C) and covered by a wet film of peritoneal fluid. The currently used gas is carbon dioxide that is instilled at 21°C and extremely dry. Altering this privileged space is a violation of surgical safety, principles, and reason. Maintaining normal healthy conditions in their original state by humidifying and warming the gas eliminates the rub of dry gas and takes arms against a sea of troubles.

Database: Literature search using PubMed and Cochrane databases identifying articles focusing on laparoscopy, pneumoperitoneum, hypothermia, evaporation, desiccation, peritoneum, and morphology.

Conclusions: Shakespeare's premonitions regarding the chilling effects and intentionally induced unhappy events perpetrated on the peritoneal cavity is not nor cannot come to good. The absence of water in the gas going into a wetted cavity causes perilous circumstances, resulting in evaporative hypothermia, tissue desiccation, and damage that precede adhesion formation. Providing the most protective canopy for the intraabdominal cavity with humidity and warmth prevents calamitous clinical outcomes and mirrors nature's intent. The virtue is in doing no harm.

Key Words: Pneumoperitoneum, Hypothermia, Humidifying, Desiccation, Peritoneum.

INTRODUCTION

Shakespeare would describe the condition of the peritoneal cavity and patient outcome like this:

To use raw, harsh unconditioned gas or not to: that is the question.

Whether 'tis nobler to suffer, the dry, cold gas of laparoscopy, its effects and outrageous misfortunes,

Or to take charge against this sea of troubles, and by harmony of sweet warmth and moisture, change, oppose and end them?

Let us take his warnings and admonitions to heart and act to bring about sweet harmony of intent and purpose and maintain homeostatic tranquility of the intraabdominal cavity.

"For this relief much thanks; 'tis bitter cold, and I am sick at heart."[1]

"All is not well…foul deeds will rise."[2]

"The air bites shrewdly, it is very cold."[3]

"Find out the cause of this effect, or rather say, the cause of this defect, for this effect defective comes by cause."[4]

The cause is dry, cool gas. The remedy is humidified, warmed gas. How are laparoscopic hypothermia, pain, and postoperative recovery connected? Let me count the ways. A common thread of these occurrences and clinical observations and their correction is the quality and condition of the gas used to create a pneumoperitoneum. The state of the standard "raw" gas used for laparoscopy contains inorganic and organic debris, is 21 degrees Celsius (°C) and bone dry.[5] The peritoneal cavity is particle free, 37°C, and constantly moist. Moistening the gas used for the pneumoperitoneum and warming to body temperature maintains a physiologic safe intraabdominal condition. During the process of creating and maintaining a pneumoperitoneum, dry gas causes rapid evaporation of the thin film peritoneal fluid layer covering the peritoneum.[6] Evaporation of the peritoneal fluid layer has desiccation effects on the delicate single cell layer of peritoneum cells.[7] The result is evaporative cooling and hypothermia and tissue damage due to desiccation.[8] A host of unintended consequences most foul (Hamlet to the ghost)

Mercer University, School of Engineering, Macon, Georgia, USA.

Address for correspondence: E-mail: gabiomed@mindspring.com

DOI: 10.4293/108680811X13071180407276

follows.[9] Peritoneal cell desiccation alters cell metabolism compromising function and viability, stresses cell structures, initiates an acute inflammatory response and may reach irretrievable damage directly or as apoptosis.

Filtering the gas to 0.2 micron removes foreign bodies and bacteria.[5] Warming the gas increases its capacity to hold moisture and reduces thermal insult. Humidification reduces the latent heat of vaporization caused by the differential between the bone-dry raw gas and the wet intraabdominal environment. Conventional raw carbon dioxide has less than 200 parts per million water vapor (0.0002 percent [%]) compared to at least 950 000 parts per million (95%) normal intraabdominal water content.[10] Humidifying and warming the gas reduce thermal losses and prevent tissue desiccation and its consequences. The unconditioned gas is cool (20°C) compared to normal body temperature (37°C). This coupled with the bone-dry gas passing over a room temperature laparoscope placed into the warm, moist abdomen causes fogging.[11] Using hydrated warmed gas keeps the intraabdominal dew point from being reached, with the lens having a better chance to stay clear and unfogged. Thermal losses from peritoneal surface evaporation are eliminated when water vapor is added to the gas.[12] Skin surfaces covered with warm air convection drapes is an inefficient method to correct for conductive and convection heat losses, because the majority of laparoscopic heat loss has its root cause from evaporative heat loss internally close to the core. External warming blankets have no effect on peritoneal evaporative losses or tissue desiccation. Moist gas eliminates peritoneal fluid changes, eliminates tissue desiccation and loss of intraperitoneal cell water, preserves peritoneal cell function and integrity and reduces the total number of acute inflammatory reactions.[13] Reducing the number of sites and surface area of iatrogenic-induced gas damaged peritoneum reduces the likelihood of de novo adhesion formation.[14] Desmotic connections between peritoneal intracellular attachments are maintained with moistened warmed gas. Preconditioned gas reduces the amount of prostaglandin and kinin release that effects tissue healing and postoperative pain occurring as a result of peritoneal cell disruption that is cumulative in effect and additive to the surgical procedure peritoneal injury.[15] The combination of reduced hypothermia, reduced peritoneal damage, and reduced inflammatory response minimizes postoperative medication requirements and shortens length of stay.[16-18] A quicker, less painful, tissue friendly, more comfortable convalescence is a desirable surgical outcome for both patients and physicians. Studies show that preconditioned humidified warmed gas is safer, less traumatic to peritoneal tissue, and more physiologic with beneficial outcomes than warmed alone or room temperature gas.[19-22]

There is no comfort in the dry-cold or dry-heated blast of impoverished gas; keep whole and preserve the peritoneum, take refuge in the sustenance of the elixir of life–water–maintain the balance, measure, and composition of the tranquil beginning, keep your charge from tragedy, wreck, and havoc, for who can be patient in extremes, secure and preserve the serenity and trust given you, your sacred oath to protect and do no harm.

References:

1. Shakespeare W. *Hamlet*. Act 1, scene 1, line 10.

2. Shakespeare W. *Hamlet*. Act 1, scene 2, lines 254-256.

3. Shakespeare W. *Hamlet*. Act 1, scene 4, line 1.

4. Shakespeare W. *Hamlet*. Act 2, scene 2, line 101.

5. Ott D. Contamination via gynecologic endoscopy insufflation. *J Gynecol Surg*. 1989;5:205-208.

6. Ott D. Laparoscopy and tribology: The effect of laparoscopic gas on peritoneal fluid. *J Am Assoc Gynecolo Laparosc*. 2001;8: 117-123.

7. Ott D. Desertification of the peritoneum by thin-film evaporation during laparoscopy. *JSLS*. 2003;7:189-195.

8. Gray R, Ott D, Henderson A, Cochran S, Roth C. Severe local hypothermia from laparoscopic gas evaporative jet cooling: A mechanism to explain clinical observations. *JSLS*. 1999;3:171-77.

9. Ott D. Laparoscopic hypothermia. *J Laparoendosc Surg*. 1991;3:127-131.

10. United States Pharmacopeia and National Formulary and Supplements, XXI-NF. 1984.

11. Lawrentstuck N, Fleshner N, Bolton D. Laparoscopic lens fogging: a review of etiology and methods to maintain a clear visual field. *J Endourol*. 2010;24:905-913.

12. Ott D, Reich H, Love B, McCorvey R, Toledo A, Liu C, Syed R, Kumar K. Reduction of laparoscopic-induced hypothermia, postoperative pain and recovery room length of stay by preconditioning gas with the Insu*flow*® device: A prospective randomized controlled multi-center study. *JSLS*. 1998;2:321-329.

13. Bessell J, Karatassas A, Patterson J, Jamieson G, Maddern G. Hypothermia induced by laparoscopic Insufflation. A randomized study in a pig model. *Surg Endosc*. 1995;9:791-796.

14. Mouton W, Bessell J, Otten K, Madern G. Pain after laparoscopy. *Surg Endosc*. 1999;13:445-448.

15. Hazebroek E, Schreve M, Visser P, De Bruin R, Marquet R, Bonjer H. Impact of temperature and humidity of carbon

dioxide pneumoperitoneum on body temperature and peritoneal morphology. *J Laparoendosc Adv Surg Tech A*. 2002;12:355-364.

16. Bessell J, Ludbrook G, Millard S, Baxter P, Ubhi S, Maddern G. Humidified gas prevents hypothermia induced by laparoscopic insufflation. *Surg Endosc*. 1999;13:101-105.

17. Peng Y, Zheng M, Ye Q, Chen X, Yu B, Liu B. Heated and humidified CO_2 prevents hypothermia, peritoneal injury and intra-abdominal adhesions during prolonged laparoscopic insufflations. *J Surg Res*. 2009;151:40-47.

18. Volz J, Koster S, Spacek Z, Paweletz N. Characteristic alterations of the peritoneum after carbon dioxide pneumoperitoneum. *Surg Endosc*. 1999;13:611-614.

19. Beste T, Daucher J, Holbert D. Humidified compared with dry, heated carbon dioxide at laparoscopy to reduce pain. *Obstet Gynecol*. 2006;107:263-268.

20. Benavides R, Wong A, Nguyen H. Improved outcomes for Lap-banding using the Insuflow device compared with heated-only gas. *JSLS*. 2009;13:302-305.

21. Sammour T, Kahokehr A, Hill A. Meta-analysis of the effect of warm humidified insufflation on pain after laparoscopy. *Br J Surg*. 2008;95:950-956.

22. Sajid M, Mallik A, Rimpel J, Bokari S, Cheek E, Baig M. Effect of heated and humidified carbon dioxide on patients after laparoscopic procedures a meta-analysis. *Surg Laparosc Endosc Percutan Tech*. 2008;18:539-546.