Why Should I Care if a Urologist Wants to Perform a Laparoscopic Radical Prostatectomy in a Patient with MH?

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OBJECTIVES

1. Describe the anesthetic implications of laparoscopic radical prostatectomy.
2. Appreciate how laparoscopic surgery alters intra-operative physiology and patient monitoring capabilities.
3. Discuss how laparoscopic urologic surgery may alter a clinician's ability to diagnose and/or treat malignant hyperthermia.
4. Understand medical indications and treatments for prostate cancer.

STEM CASE - KEY QUESTIONS

A 58 year old man arrives in your anesthetic holding area for a laparoscopic radical prostatectomy. His accompanying medical information indicates he has suffered a previous myocardial infarction and subsequently underwent a coronary angioplasty six years ago. He smoked two packages of cigarettes daily from age eleven until his myocardial infarction. As soon as you greet him he states his son is muscle-biopsy positive for malignant hyperthermia.

Case Specifics:

This 58 year old man is lying on a stretcher in the preoperative holding area accompanied by his wife. He is to be your second case of the day. As you interview him you learn he smoked for 41 years at a rate of two packages per day, but stopped six years ago after his angioplasty. He is a "social" drinker, uses no herbal medications or supplements, but takes a diuretic for mild hypertension and discontinued his "baby" aspirin one week ago. He has no allergies to foods or latex containing products, but admits to an allergy to "statins", as they produced muscle pains. He states he had a knee operation eighteen years ago and recalls no problems, but he doesn't recall the anesthetic because he doesn't even remember going into the operating room.

Following his myocardial infarction and subsequent coronary angioplasty he has no angina and is actively doing restoration work on his home. His prostate cancer was detected after rising prostatic specific antigen levels led to a prostate biopsy that was reported as Gleason Grade 6. He does admit to one episode of "heat stroke" when he was a college student vacationing in Florida on spring break. He spent the day in the sun and feels he "had a little too much to drink while continuously playing beach sports".

A physical examination reveals an extremely anxious but healthy-appearing man with no specific abnormalities. Laboratory studies include a CBC, electrolytes, BUN and createnine. All are within normal limits. His electrocardiogram is consistent with a previous inferior wall myocardial infarction, and additionally demonstrates left ventricular hypertrophy with nonspecific S and ST wave changes.

He is quite worried because his twenty-one year old son suffered a severe febrile event during an emergent repair of femur and humerus fractures after an automobile accident when he was nine years old. Six months later a muscle biopsy was performed and the report notes the muscle

contracted to both halothane and caffeine; it was interpreted as consistent with malignant hyperthermia susceptibility. (The patient's two older children have had no operations requiring anesthesia.) The patient states he showed this report to his surgeon. The surgeon told him he could find no information during an internet search combining malignant hyperthermia and laparoscopic surgery. He then asks you how you will deal with this issue. Next his wife asks whether you have Dantrolene available. Finally, he states that if he can't have this surgery by a laparoscopic approach, he will return to his local hospital because he has a "great surgeon who can do the classical open resection."

What do you tell the patient and his wife?

What do you tell the surgeon?

What will you do regarding the anesthesia care?

As you prepare to answer these questions consider whether either laparoscopic or "open" prostatectomy is the "best" treatment for this man with this disease grade at his age. Then consider how your choice of anesthesia may affect management or treatment decisions for this patient given his son's history of MH.

Case Management and Key Questions:

Assume you have agreed to proceed.

1. What type of anesthetic will you use and why? What drugs will you use or avoid?

2. How will you monitor this patient? Do you need any "non-standard" monitoring (invasive or other type), and if so, why?

3. Describe surgical positioning and how it will influence your anesthetic management.

4. If you have chosen a general anesthetic, will you use nitrous oxide? Why or why not? What total gas flow will you use? Why?

5. If you have chosen a general anesthetic, how will you ventilate this man? Will you need to change ventilation as the capnoperitoneum develops? If so, will it be by changing tidal volume or ventilator rate? How will changing either parameter effect your ability to maintain or assess that you have an acceptable level of CO_2? How might this man's history affect your choice?

6. Will you use any type of patient warming technique? Why or why not? Will warming insufflating gas help raise body temperature or have other beneficial/harmful effects?

The anesthetic has now started. You are satisfied with the patient's responses so far. If you are using a processed EEG anesthetic depth monitor, its reading is acceptable. The surgeon has performed the skin preparation and has draped the patient. He is ready to insufflate the abdomen for the laparoscopy.

1. Will creating a pneumoperitoneum with CO_2 alter your ability to diagnose malignant hyperthermia? If so, how?

2. What alternatives to CO_2 pneumoperitoneum exist? What are their advantages and disadvantages? How easily can they be instituted?

3. Describe the cardiovascular, respiratory, renal, and splanchnic organ effects of pneumoperitoneum. How do central vascular pressures (both right and left heart) change with pneumoperitoneum? What, if any, is the relation between changing pneumoperitoneum pressure and central vascular pressures? Are there differences with body position?

4. Will you be able to measure urine output during this procedure? How does this operation and pneumoperitoneum affect your ability to measure and interpret urine output during laparoscopic procedures, in general?

The surgeon has now insufflated the abdomen to a pressure of 20 mmHg and asks you to place the patient in maximal Trendelenberg position.

1. What level of pneumoperitoneum is acceptable, what is “best”, and how high is “too high”? What are the advantages/disadvantages to surgeons and anesthetists of higher pneumoperitoneum pressures?

2. What are the effects of Trendelenberg position on the cardiovascular and respiratory systems?

About fifteen minutes later you notice the EKG has changed: the R-wave has increased in size and the S-wave has decreased. Both changes have occurred in lead I and in lead V_5. Additionally the oxygen saturation has decreased to 92% with an unchanged 66% inspired concentration of nitrous oxide. What, if anything, will you do to treat these changes?

The case is now proceeding smoothly. You have been about two and a half hours since induction. The surgeon is partway through the reanastomosis of the bladder to the distal urethra, after which the surgeon will make a small incision midway between the umbilicus and pubis to remove the prostate. Then this incision and all port sites will be closed and surgery will end. Thus, about 15 minutes ago you have given 25 mg of meperedine and slightly reduced your anesthetic level in anticipation of ending the anesthetic.

The surgeon just then looks over the ether screen and tells you the patient is “tight”. When you check vital signs you notice the end-tidal CO_2 has increased by about 5 mmHg from the last reading nearly 15 minutes ago, the patient is making breathing efforts and his peak inspiratory presures have increased.

1. Describe how you will respond. Specifically, describe all possible differential diagnoses, and how you can support or refute each one. Explain which diagnosis is most likely and how you will treat it.

2. Discuss the cardiovascular effects of increased (arterial, alveolar or end-tidal) CO_2.

The situation has now resolved with your treatment. The operation is complete and you are preparing to end your anesthetic. Describe any specific differences in management while this patient is in the recovery room.

PROBLEM BASED LEARNING DISCUSSION

I. ANESTHETIC IMPLICATIONS OF LAPAROSCOPIC RADICAL PROSTATECTOMY:

A. General Aspects:

1. Positioning: Trendelenberg vs reverse Trendelenberg; Arm position.
2. Patient access. Is it affected by patient positioning, and if so, how?
3. Describe patient monitoring, appropriate/required vascular access, average blood loss and surgical duration. Are there any other issues specific to this operation?

B. Respiratory:

1. What is the physiologic basis for, and magnitude of, changes during laparoscopy in the respiratory parameters listed below. Please use tools such as: pressure-volume diagrams of the respiratory system, lung and chest wall; single breath CO_2 curve; Konno-Mead diagram; etc.
    a. Peak inspiratory pressure; Dynamic compliance; Minute ventilation; Respiratory rate; Expiratory flow; End-tidal CO_2; Arterial CO_2; V_D/V_T; $P_{a\text{-}ET}CO_2$; P_aCO_2; Q_S/Q_T; V_ECO_2; Respiratory quotient; Functional residual capacity.
2. Describe CO_2 kinetics during carbon dioxide pneumoperitoneum.
3. Is lung disease a risk factor for intra-operative ventilation problems? What data support or refute your answer?

C. Cardiac:

1. Describe the physiologic basis for cardiovascular system effects of pneumoperitoneum using concepts such as the Frank-Starling cardiac performance curve and “venous return” curves.. Please discuss each of the following measurements and how a “vascular waterfall” could/does affect them:
    a. Mean arterial pressure; Cardiac index; Systemic vascular resistance; Central venous pressure; Pulmonary capillary occlusion (wedge) pressure; Mean pulmonary artery pressure; Pulmonary vascular resistance.
2. Why are changes in cardiac filling pressures less than the increase in pneumoperitoneum pressure? Do these changes with pneumoperitoneum differ between right and left sides of the heart, and how does body position affect these changes?
3. How much of these changes are due to CO_2 rather than the pneumoperitoneum?

D. Renal:

1. Does pneumoperitoneum alter urine output? If so, how, why, and for how long? Can it be overcome?
2. How does a laparoscopic radical prostatectomy specifically alter your ability to measure/collect urine output?
3. What is the implication of this operation to urine color/analysis in the postoperative period? How might this alter your management?

II. MALIGNANT HYPERTHERMIA:

A. Describe current knowledge regarding its causes.
1. What causes MH, in the porcine stress model and in humans?
   a. Please describe genetic differences.
2. Describe any differences relating to the following issues:
   a. What are its triggers?
   b. How does it present?
   c. What other complications occur?

B. How can MH be diagnosed and what other conditions must be included in its differential diagnosis?

C. How might using closed circuit/ultra low flow anesthesia help you make a diagnosis of MH?

D. What aspects of laparoscopic surgery could alter your ability to diagnose or treat MH?

E. Should an insufflation gas other than carbon dioxide be used?
1. If so, what are the alternatives, implications and ease of switching to a different insufflating gas?
   a. What are the side effects and benefits of CO_2 as in insufflant?
   b. What effects of pneumoperitoneum would be different if a gas other than CO_2 were used for insufflation? For example, N_2O, an "inert" gas?
2. What are the benefits and problems associated with Abdominal Wall Lift?

III. DESCRIBE THE RISKS AND BENEFITS OF SURGICAL TREATMENT FOR PROSTATE CANCER:

A. How has the prostate specific antigen (PSA) assay altered management/diagnosis of prostate cancer?
1. What is PSA and what different subtests exist?
2. Has it reduced mortality?
3. What is the "natural" course of prostatic cancer?
4. Is there an age- or race-specific risk for prostate cancer?

B. How does the Gleason score determine patient outcome?
1. What is the Gleason score and how is it determined?

C. What treatment options (surgical and non-surgical) exist for prostate cancer?
1. What are the implications of each treatment option for the anesthesiologist?
2. Describe requirements unique to doing this operation with a laparoscope.

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LEARNING SUMMARY

A man with a family history of malignant hyperthermia (MH) will illustrate anesthetic management and treatment options for laparoscopic surgery using radical prostatectomy as an example. Participants will consider physiologically how and why pneumoperitoneum effects cardiac, respiratory and renal systems, and whether MH might present a relative contraindication to laparoscopic surgery.