

Laparoscopy: Physiology & Complications

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Disclosures

- Avvio Medical: Primary Investigator and Consultant
- Novo Nordisk: Scientific Advisor



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Acknowledgements

AUA Core Curriculum

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Core Curriculum

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Learning Objectives

(what I want you to be able to do after this lecture)

- Describe the physiologic effects of pneumoperitoneum
- Identify and manage complications related to pneumoperitoneum
- Optimize patient positioning to prevent neuromuscular complications
- Prevent, recognize and address complications that arise during laparoscopic and robotic surgery



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Physiology



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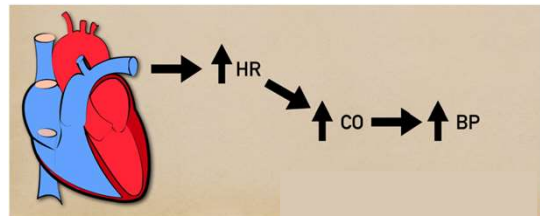
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Carbon Dioxide

- Most common insufflation gas
- Nonflammable; cleared by exhalation

- **Sympathetic stimulation**

- Increases HR, cardiac contractility & vascular resistance
- Watch for arrhythmias
 - Bradyarrhythmias from vagal stimulation or tachyarrhythmias from hypercarbia



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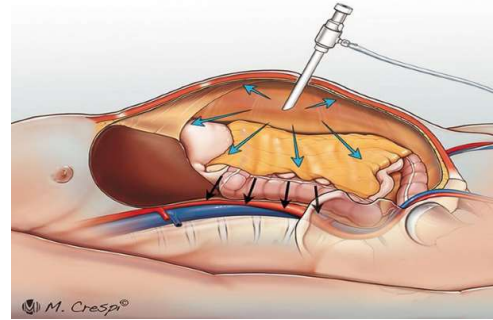
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Cardiovascular Effects of Pneumoperitoneum (< 20 mm Hg)

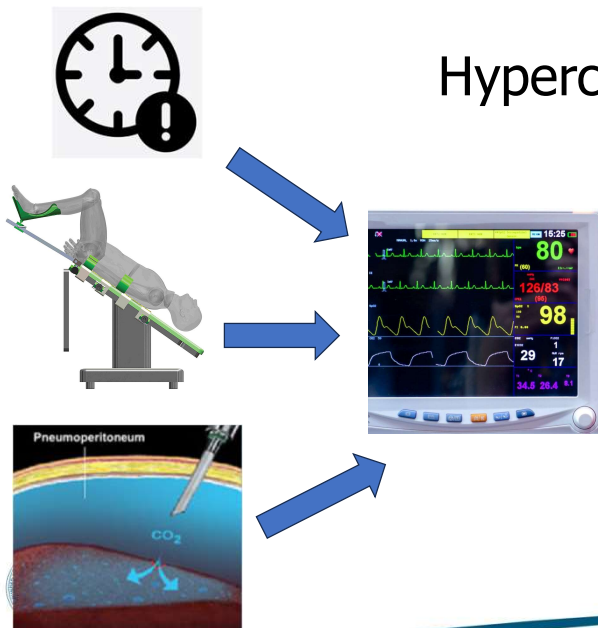
- Normal or hypovolemic state (low atrial pressure)
 - Venous return is decreased 2^o to compression of the vena cava
 - Decreases cardiac output
- Hypervolemic state (high atrial pressure)
 - Venous return is increased



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Hypercarbia



- CO₂ soluble in water and diffuses into tissues
- Dangerous in patients with COPD
 - Impaired ability to release CO₂
- **Metabolic acidosis**
- Rx: increase minute ventilation

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Positioning



Hemodynamic Parameter	Head up
Heart rate	↑
Mean arterial pressure	↓
Systemic vascular resistance	↑
Cardiac output	↓
Intracranial pressure	↓



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Positioning



Hemodynamic Parameter	Head up	Head down
Heart rate	↑	↓
Mean arterial pressure	↓	↑
Systemic vascular resistance	↑	↓
Cardiac output	↓	↑
Intracranial pressure	↓	↑





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Positioning

Hemodynamic Parameter	Head up	Head down
Heart rate	↑	↓
Mean arterial pressure	↓	↑
Systemic vascular resistance	↑	↓
Cardiac output	↓	↑
Intracranial pressure	↓	↑



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Respiratory Effects of Pneumoperitoneum

- Diaphragmatic motion is limited
 - Predisposes to atelectasis
- Peak airway pressures increases
- Decreases FRC and compliance

Parameter	Change
Peak inspiratory pressure	↑
Chest wall mechanical resistance	↑
Pulmonary compliance	↓
Pulmonary dead space	↔
Functional reserve capacity	↓
Vital capacity	↓



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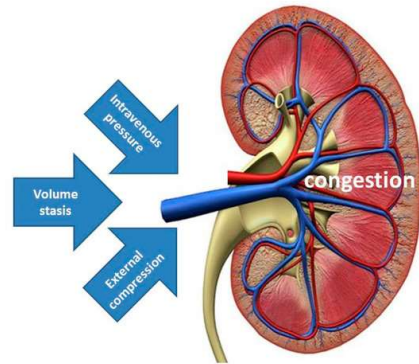
Renal Effects of Pneumoperitoneum

- Compression of renal vasculature and decreased cardiac output causes:

- **Decreased renal blood flow**
- **Increased ADH**

- Results in:

- **Oliguria**
- **Decreased GFR**
- **Increased water reabsorption**



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Dreesen P et al.. Increased Intra-Abdominal Pressure During Laparoscopic Pneumoperitoneum Enhances Albuminuria via Renal Venous Congestion, Illustrating Pathophysiological Aspects of High Output Preeclampsia. *Journal of Clinical Medicine*. 2020; 9(2):487

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Summary of Physiologic Effects of Pneumoperitoneum

Parameter	Change
HR	↔, ↑
MAP	↑
SVR	↑
Venous return	↓
CVP	↑
CO	↔, ↓
GFR	↓
UO	↓

Parameter	Change
Peak insp press	↑
Chest wall mechanical resistance	↑
Pulm compliance	↓
Pulm dead space	↔
Functional reserve capacity	↓
Vital capacity	↓



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Complications

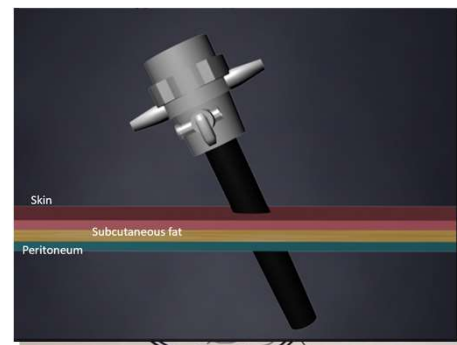


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Subcutaneous Emphysema

- Leakage around trocars and diffusion into the subcutaneous space
 - Caution in obese patients
- Common causes
 - Incorrect Veress needle placement
 - Trocar site is too large
 - Lengthy cases
 - High pressures & high-flow insufflators



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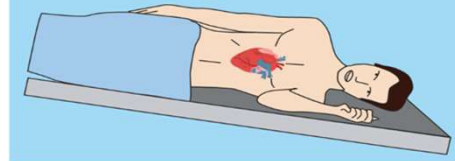
CO2 Embolism

- Puncture of a blood vessel or organ with the Veress
- Diagnosis:
 - Acute cardiovascular collapse
 - Increased end-tidal CO2
 - Decreased oxygen saturation, then marked decrease in end-tidal CO2
 - **"mill-wheel" murmur**



Treatment

- Head low
- Left lateral trendelenburg
- Air bubbles accumulate in RV apex away from pulmonary conus.



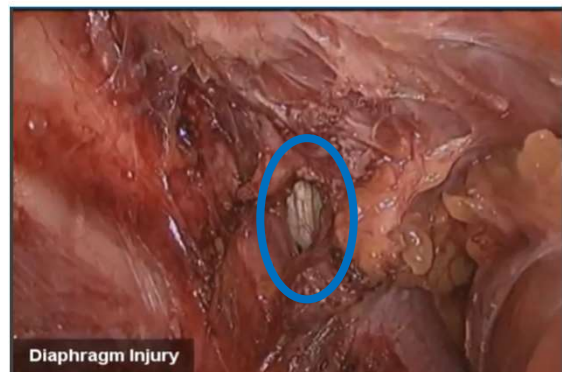
100% O2, Central line?

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Pneumothorax

- Spontaneous or diaphragmatic injury
 - Sudden rise in mean airway pressure
 - Decreased O2 saturation
 - "Floppy" Diaphragm
 - Post-op CXR
- Treatment:
 - If Dx'ed post-op and Asx, observe
 - If recognized, repair (+/- chest tube)



Diaphragm Injury



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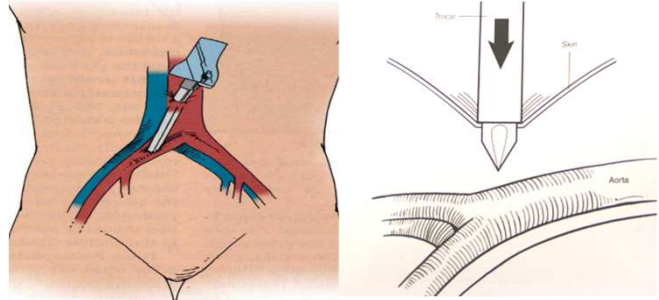
Access injuries – Major Vascular

- Proper Veress and trocar technique

- Avoid bladed trocars!

- Direct puncture injuries to:

- Right common iliac artery or vein
- Aorta (bifurcation at umbilicus)
- Inferior Vena Cava
- Mesenteric vessels



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Access injuries – Minor Vascular

- Inferior epigastric artery

- Recognition is key

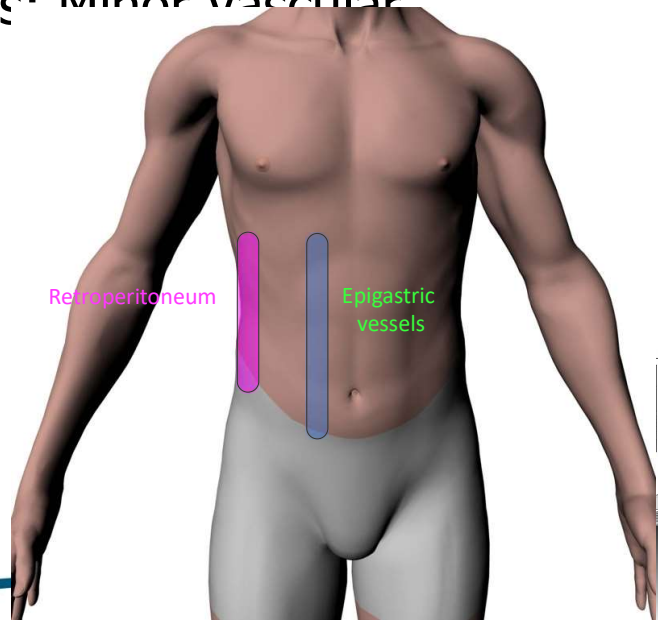
- Inspect trocar sites at end of case

- Control with Veress

- If not, small open incision

Retroperitoneum

Epigastric vessels



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Open Trocar Insertion

- No major vascular injuries reported with open insertion technique
- No deaths reported for open insertion technique
- Could use a small gel access port



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Bleeding During Surgery



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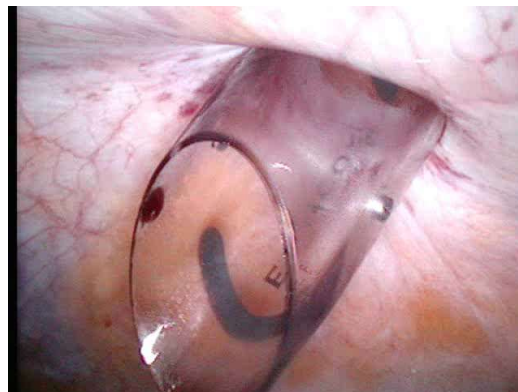
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Removal of Trocars

- Visual guidance
- Check for bleeding after removal which may have been tamponaded by trocar
- Close fascia for ≥ 10 mm ports
 - 5mm in children



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Patient Positioning

- General Principles
 - OG tube
 - Foley
 - Padding
 - Secure to bed
- Upper Tract
 - Modified Lateral
 - Arm board vs pillow vs pink foam
 - No axillary roll
 - No kidney rest or flexion*



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Nerve Injury

- Femoral nerve
 - Hyperextension of hip
 - robotic pelvic procedures
 - Sensory: anteromedial thigh
 - Motor: hip flexion
- Obturator nerve
 - Sensory: medial aspect of the thigh
 - Motor: adduction of the thigh
- Lateral femoral cutaneous
 - Sensory only: lateral thigh
- Sciatic nerve
 - Sensory: posterior calf
 - Motor: posterior thigh
- Genitofemoral nerve
 - Sensory: scrotal/labial skin
 - Motor: cremaster muscle

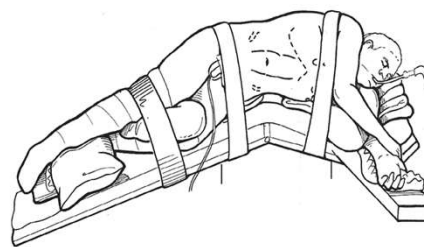


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Injuries related to positioning

- Nerve Injuries
 - Be mindful of neutral position
 - Classic is paresthesia but can have weakness
 - Recovers with time +/- PT
- Pressure-related: think time and habitus
 - Compartment Syndrome
 - **Rhabdomyolysis**
 - Diagnose with CK; Treat with bicarb fluids
 - Bony / Joint Injury



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Bowel Injury

- May take up to 18 days to develop
- Fever, nausea, emesis, ileus
- Pain **localizing to a port site** and **out of proportion to exam**
- **Leukocytosis or Leukopenia**
- KUB or CT with oral contrast (free air??)

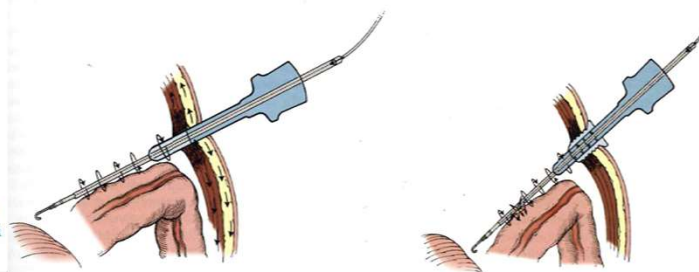


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Bowel Injury Capacitive Coupling

- Charges surrounding an activated instrument build in metal cannulas when insulated
 - Ex: placing a metal trocar within a plastic sheath
- Ultimately being discharged to an organ in close proximity



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Understand how your instrument works

- Monopolar electrocautery
 - Water (blood) is the best conductor
 - Keep entire active (metal) portion of the instrument in view during activation
- Ultrasonic device
 - Active blade gets hot



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Chylous Ascites

- Cause: disruption of major para-aortic lymphatics leading to the cysterna chyli
 - usually **left-sided procedures (nephrectomy and RPLND)**
- Presentation: abdominal distention, no pain, afebrile, and normal bowel habits
- Diagnosis: paracentesis with fluid showing **high TGs** +/- elevated lymphocytes
- Treatment: **low-fat medium-chain triglyceride diet**. +/- percutaneous drainage.
 - If unsuccessful then bowel rest, TPN and octreotide.



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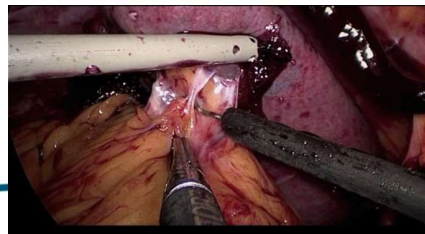
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Other Visceral Injures

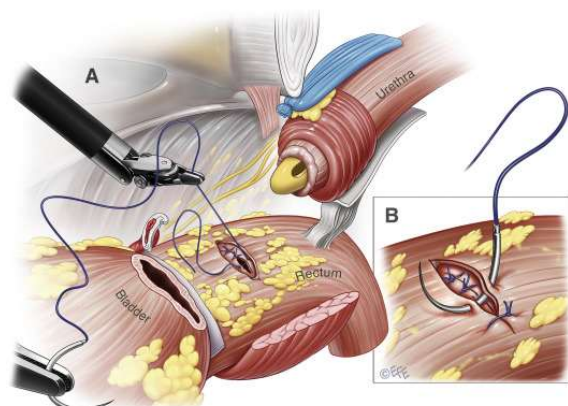
- Liver Injury
 - Pressure and hemostatic adjuncts
 - Argon
- Spleen Injury
 - Similar but less likely to work
- Pancreas Injury
 - Don't spank the panc



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RALP Rectal Injury

- Irrigate
- Close in multiple layers
- Consider use of interposition
- Leave drain and broad Abx
- If gross fecal spillage → divert



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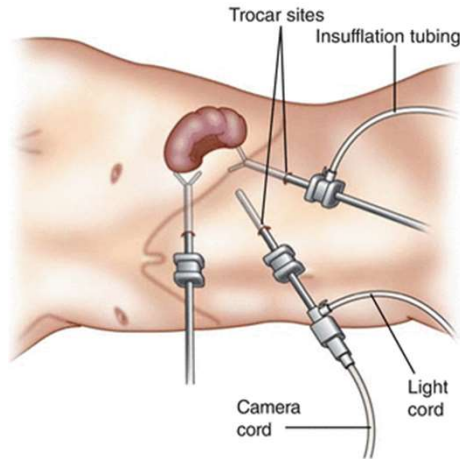
Canda, AE et al. Rectal Injury During Radical Prostatectomy: Focus on Robotic Surgery. European Urology Oncology, Volume 1, Issue 6, 507 - 509

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THANK YOU FOR YOUR ATTENTION!



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Question 1

With a pneumoperitoneum of 15 mm-Hg the following changes would be expected:

	Heart Rate	GFR	MAP
A	↑	↓	↑
B	↑	↓	↓
C	↑	↑	↓
D	↓	↑	↓
E	↓	↓	↑



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Question 2

A morbidly obese woman has crepitus along the abdomen and thorax and mild hypercarbia four hours into a laparoscopic radical nephrectomy. The next step is:

- A. Confirm trocars are in the intraperitoneal location
- B. Relocate gas insufflation to a different trocar
- C. Increased respiratory rate
- D. Increase tidal volume
- E. Convert to open nephrectomy



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Question 3

A 45-year-old woman becomes hypotensive during an attempt at laparoscopic removal of a non-functioning, hydronephrotic kidney. There is no evidence of intra-abdominal bleeding. Oxygen saturation dramatically decreases, and she develops a new heart murmur. The next step is to:

- A. Reduce the insufflation pressure; continue procedure
- B. Insert bilateral chest tubes
- C. Insert Swan-Ganz catheter
- D. Place patient in the right lateral decubitus position with head up
- E. Stop insufflation and release pneumoperitoneum



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Question 4

The vessel at greatest risk for injury during laparoscopic placement of an umbilical trocar is the:

- A. Right common iliac vein
- B. Vena cava
- C. Abdominal aorta
- D. Right common iliac artery
- E. Inferior mesenteric artery



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Question 5

70 obese M has difficulty walking one day following robotic cystectomy and pelvic lymphadenectomy. On examination, his extremities appear normal with slight decreased sensation of the anteromedial thigh and weakness bilaterally with hip flexion. The most likely cause for his symptoms is injury to which nerve:

- A. Obturator
- B. Femoral
- C. Lateral femoral cutaneous
- D. Sciatic
- E. Genitofemoral



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Question 6

A man with a BMI of 35 complains of left flank and hip pain after undergoing laparoscopic right nephrectomy in the lateral position. The surgery was challenging and required use of the kidney rest for an extended period of time. Postoperatively, he appears to have brownish-red urine. Urine dipstick is 3 for blood but no RBCs are seen microscopically. The next step is:

- A. Observation
- B. Nephrology consultation
- C. I.V. hydration and alkalinization
- D. Radiographic imaging of the hip
- E. Initiation of patient-controlled anesthesia



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Question 7

A 57-year-old man develops fever, nausea and increasing abdominal pain seven days following a laparoscopic nephrectomy. Despite bowel rest and antibiotics, he develops worsening symptoms. A KUB reveals free air in the abdominal cavity with dilated loops of small bowel.

The next step is:

- A. Abdominal ultrasound
- B. Barium enema
- C. CT scan of the abdomen with I.V. contrast
- D. CT scan of the abdomen with oral contrast
- E. Immediate surgical exploration

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Question 8

During robotic cystectomy, the assistant places an extra-long 8 mm metal robotic trocar within a previously placed standard 12 mm plastic trocar to facilitate use an additional robotic arm for dissection. The use of monopolar scissors within this hybrid trocar creates a higher risk of:

- A. Trocar dislodgement
- B. Trocar site pain
- C. Incisional hernia
- D. Thermal injury to bowel
- E. Vascular injury



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Question 9

During laparoscopic live donor nephrectomy, the kidney becomes visibly pale with loss of turgor after 15 minutes of hilar dissection.

The next step is:

- A. Reduce insufflation pressure
- B. Fluid bolus
- C. Intra-arterial papaverine
- D. Systemic heparin



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Question 10

A 25-year-old woman has mild abdominal pain and distention two weeks after a laparoscopic donor nephrectomy. She is afebrile with normal vital signs. A CT scan shows ascites. Paracentesis is most likely to show elevated:

- A. RBC's
- B. Creatinine
- C. Triglycerides
- D. Amylase



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