Anesthetic Considerations For Robotic Surgery

Warning Will Robinson, Warning

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Definition
• Describes an autonomous device capable of various tasks
• Industrial robots
• Stereotactic navigation assist device
• Telemanipulators

Robots

History

Josef Capek-1917
• Opilec

Karel Capek-1921
• Rossum’s Universal Robots (RUR)
History

• GM Introduces Unimate-1958
• Isaac Asimov 1938-1942

History

• NASA Developed Robots For Space
• Telemanipulators Capable Of Doing Manual Tasks
• Dexterous Telemanipulators For Surgical Use

History

• Department Of Defense Investigates Robots For Treating Battlefield Wounded
• Latency Of The Signal Over Distance Limited Its Effectiveness
• 1985-First Surgical Application Using Modified Industrial Robotic Arm

Laparoscopy

Phillipe Mouret - 1987

• First Video Laparoscopic Cholecystectomy

Advantages

• Reduced Tissue Trauma
• Reduced Postoperative Pain
• More Rapid Recovery
• Shorter Hospital Stay
• Improved Patient Satisfaction

Robodoc-1992

• Used In Orthopedics
• Fulcrum Effect

• Non-intuitive Motion Of The Instrument Tips In Opposite Direction About A Fixed Point

AESOP And TISKA Endoarm

1994
Development of Active Robotics

- Overcoming Dexterity Problems
- Development Of Manipulators That Mimick Hand Movements
- Development Of Three Dimensional Video Imaging, Robot Camera Holders And Robotic Flexible Instrumentation

Two Robotic Systems

da Vinci

Zeus

First Robotic-Assisted Surgical Procedure
April 1997

Jacques Himpens
Guy Cardiere

The da Vinci Robotic Surgical System

Advantages of Robotic Surgery

- Magnified 3D Vision
- Digitalized Hand Movements
- Superior Maneuverability Of Robotic Instruments
- Safety System Prevents Un-attended Movement Of Arms

Disadvantages Of Robotic Surgery

- Bulky, Large Equipment
- Costly
- Instrumentation Has Finite Life Of Ten Procedures
- Invasion Of Anesthetic Work Space
- Loss Of Tactile Feedback
- Requires Staff Training
Procedures Performed Using Robotics

- GI Procedures
  - Cholecystectomy
  - Gastrectomy, Gastric Bypass, Pancreatoduodenectomy
  - Colon Resection
- Thoracic
  - Lobectomy And Wedge Resection
  - Esophagastrectomy
  - Thymectomy
- Cardiac
  - Coronary Bypass Graft
  - Atrial Septal Defect Repair
  - Mitral Valve Replacement
- Otolaryngology
- Orthopedics
- Ophthalmology

Initiating A Robotic Program

- Major Financial Outlay And Recurring Cost
- Surgical Growth Potential And Recognition Offsets The Cost Of The Program
- Teamwork Is Essential To Success
- Challenges Include
  - Increased Operating Time
  - Surgical Learning Curve

Prostate Cancer

- Affects 235,000 Annually
- Death Rate Approximates 12%
- Treatment Options Include:
  - Radiation
  - Observation
  - Surgery

Radical Prostatectomy

- Changes Quality Of Life
- Discourages Treatment
- Complications From Damage To Urinary Sphincter And Penile Nerve
- Minimally Invasive Technique
  - Nerve-Sparing Technique
  - Has Increased Patient Acceptance
  - Allows More Rapid Discharge

On The Horizon?

Robot-Assisted Regional Anesthesia: A Simulated Demonstration

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‡Department of Urology, University of Florida College of Medicine, and National Institutes of Health (NIH) grant UL1 RR025759.
### Differences Between Robotic And Laparoscopic Surgery
- Challenges To Patient Access
- Securing And Preventing Patient Movement
- Importance Of Adequate Muscle Relaxation

### Anesthesia Considerations
- Patient Positioning
- Hemodynamic And Respiratory Effects Of Pneumoperitoneum
- Duration Of Procedure
- Spatial Restrictions Due To Equipment
- Possibility Of Unsuspected Visceral Injury Or Blood Loss
- Development Of Hypothermia

### Positioning
- Robot May Be Positioned At The Feet, Side Or Close To Head
- Once Robot Is Engaged, Bed And Patient Position Cannot Be Changed
- Protect The Patient From Pressure And Crush Injuries From Robotic Arms

### Protecting Your Patient From Nerve Injury
- 2.7% Incidence Of Neuromuscular Injury Annually
  - Radial And Ulnar Nerves
  - Brachial Plexus
  - Sciatic Nerve
  - Obturator Nerve
  - Peroneal Nerve
  - Lateral Femoral Cutaneous Nerve
- Pad All Areas

### Protecting Your Patient From Nerve Injury
- Patient Strapped With Chest Binding In X Pattern
- Protect The Face

### Positioning In Trendelenburg
- Gel Mat Placed Under Patient To Minimize Slipping And Provide Padding
- Bean Bag Is An Option But Rarely Used
- Avoid Use Of Shoulder Braces
Positioning In Lithotomy

• Goal Is To Minimize Hip Abduction And Maximize Flexion To Accommodate Robot Arms
• Cushioned Stirrups
• Arms And Hands Padded And Tucked
• Ensure IV Access And Functional Monitoring Ability
• Only Opportunity To Gain Access For IVs And Invasive Monitors Is Before Docking

Positioning In Lateral Position

• Axillary Roll Placed
• Kidney Rest Positioned Over Iliac Crest
• Prevents Lung Splinting And Atelectasis
• Plan On Variations Of Trendelenburg Or Reverse Trendelenburg

Effects Of Trendelenburg

• Abdominal Contents Push Diaphragm Cephalad
• Increased Pulmonary Blood Content And Gravitational Force On Mediastinal Structures
• Swelling Of Face, Eyelids, Conjunctivae, And Tongue
• Pharyngeal And Laryngeal Edema Is Possible

Pulmonary Effects of Trendelenburg

• Increased CVP, Myocardial Work And Pulmonary Vascular Resistance
• Increased SV, CO
• MAP Unchanged Or Slightly Increased
• Increased Cerebral Venous Pressure
  • Decrease In CBF

Cardiovascular Effects of Trendelenburg

• Well Tolerated By Health Individuals
• Myriad Of Issues
  • Cardiovascular Effects
  • Pulmonary Effects

Effects Of Pneumoperitoneum
Cardiovascular Effects Of Pneumoperitoneum

- Increase in intraabdominal pressure causes:
  - Compression of vena cava
  - Increase in SVR, MAP, HR, PVR
  - Increase in CVP, PCWP, PAP
  - Decrease in SV, CO, CI
- Pronounced in patients with pre-existing disease

Pulmonary Effects Of Pneumoperitoneum

- Elevation of diaphragm
- Decreased FRC
- Peak pressure, plateau pressure and intrathoracic pressure increase by more than 50%
- Decreased compliance up to 68%
- V-Q mismatch
- Pulmonary shunting
- CO2 absorption hypercarbia and acidosis corrected with ventilation

Comparative Effects

<table>
<thead>
<tr>
<th>Trendelenburg</th>
<th>Pneumoperitoneum</th>
</tr>
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<tbody>
<tr>
<td>↑ SV</td>
<td>↓ SV</td>
</tr>
<tr>
<td>↑ CO</td>
<td>↓ CO</td>
</tr>
<tr>
<td>↑ CVP</td>
<td>↑ CVP</td>
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<tr>
<td>± MAP or slightly ↑</td>
<td>↑ MAP</td>
</tr>
<tr>
<td>↓ FRC</td>
<td>↓ FRC</td>
</tr>
<tr>
<td>↓ Compliance</td>
<td>↓ Compliance</td>
</tr>
<tr>
<td>↓ CBF, ICP</td>
<td>↑ CBF, ICP</td>
</tr>
</tbody>
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Combined Effects Of Pneumoperitoneum And Trendelenburg

- MAP decreased 17%
- HR decreased 21%
- CO decreased 10-30%
- 27% of patients experience dysrhythmias

Hepatic Effects Of Pneumoperitoneum

- Decreased portal vein flow
- Decreased hepatic vein flow
- Decreased total hepatic blood flow and flow through hepatic microcirculation
- No change in hepatic arterial flow

GI and Renal Effects Of Pneumoperitoneum

- Decreased gastric PH
- Decreased mesenteric blood flow and microcirculation
- Decreased renal blood flow
CNS Effects Of Pneumoperitoneum

- Increased CBF
- Increased ICP
- Decreased CPP

Complications Of Pneumoperitoneum

- Subcutaneous Emphysema
- Pneumothorax
- Cephalad Shift Of Diaphragm
- Venous Gas Embolism

Venous Gas Embolism

Caused By Rapid Insufflation Into Vessel
- Mill-wheel Murmur
- Hypoxia
- Decreased CO₂
- Cyanosis
- Sudden Cardiac Collapse

Treatment
- Removal Of Pneumoperitoneum
- Hyperventilation With Oxygen
- Left Lateral Decubitus And Trendelenburg Position
- Aspiration Of Air Via CVP

Anesthesia Management

- Everyone Is Not A Candidate
- Proper Screening Will Minimize Complications Of Positioning And Pneumoperitoneum

Pre-operative Evaluation

- Optimization Of Cardiorespiratory And Metabolic System
- Discontinuation Of Anti-coagulants
- Identify Past History Of Abdominal Surgery
- Document Pre-existing Nerve Injury

Obesity And Robotics

- Predisposed To HTN, CAD, DM
- Challenge On Pulmonary Physiology
- Hindrance On Diaphragmatic Movement
- Difficulty Achieving Minute Ventilation
Intra-operative Management

• No Specific Technique Or Drug Preference
• Standard Monitors
  • Consider Arterial Line Placement
• Regional Anesthesia Not Indicated

Ventilation

• Increase In Airway Pressures
• Augmented In Patients With Restrictive Or Obstructive Disease
• Utilize Pressure Controlled Ventilation Provides Better Ventilation And Lower Peak Airway Pressures Over Volume Control Mode

Muscle Relaxation

• Complete Muscle Relaxation Is Essential
• Spontaneously Breathing Diaphragm Causes Abdominal Contents To Move
• Facilitates Ease Of Mechanical Ventilation
• Facilitates Introduction Of Surgical Equipment
• Eases Creation Of Pneumoperitonium
• Consider Using Continuous Infusion

Special Considerations

Anesthetic Considerations For Robotic-Assisted Thoracoscopy

• Same Principles Apply As Thoracoscopic Surgery
• Improved Patient Outcome
• Selection Criteria Limited
• Side Cart Is Positioned Close To Head
• Limited Access To Airway And Neck

Anesthetic Considerations For Robotic-Assisted Thoracoscopy

• Insufflation Of CO₂ In The Chest Increases Airway Pressures
• Venous Return And Compliance Of Heart Decreases Resulting In:
  • Hypotension And Hemodynamic Instability
  • Dependent Lung Develops Higher Airway Pressures
• CO₂ Rapidly Absorbed
Anesthetic Considerations For Robotic-Assisted Thoracoscopy

- One Lung Ventilation And Manipulation Alter Ventilation And Perfusion
- Lateral Position Reduces Shunting To Non-dependent Lung
- Pulmonary Shunting In Non-ventilated Lung Limited By HPV

Complications Of Thoracic Insufflation

- Emergency Conversion To Open Procedure
- Contra-lateral Pleural Can Be Violated Creating Tension Pneumothorax In Dependent Chest
  - CO2 Discontinued To Alleviate Tension Pneumothorax

Gynecologic Surgery

- Marked Improvement Over Laparoscopic Procedures
- Improved Micro-surgical Techniques

Otolaryngology Surgery

- Posterior Pharyngeal Resection
- Total Laryngectomy
- Field Avoidance
- Protection Of Airway

Fluids

- Minimizes Facial Edema
- Restricted To Prevent Obscuring Surgical Field During Resection Of Bladder Neck
- Restoration Of Volume Possible After Return To Supine Position

"Mr. Osborne, may I be excused? My brain is full."
Summary

- Learning Curve For The Surgeon
- Positioning And Pneumoperitoneum Provide A Great Challenge
- Robotics Gives New Meaning To Field Avoidance
- Patient Satisfaction And Surgical Outcomes High
- Much More Lies Over The Horizon