Enhanced Recovery After Surgery (ERAS)

Coming Soon to an Operating Room Near You

Maria Hirsch, DNAP, CRNA

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ERAS - What is it?

- AKA - "ERP" enhanced recovery programs or "fast-track" surgery
- Multimodal perioperative care program
  - Series of perioperative protocols that aim to improve the patient's ability to face major operations and facilitate postoperative recovery

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ERAS

- ERAS interventions focus on key factors that usually keep patients in the hospital longer, dependent on drugs & specialized assistance
  - Parenteral analgesia
  - IV fluid administration
  - Confinement to bed

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Development of ERAS

- Initiated by Professor Henrik Kehlet in Denmark the 1990s - "Fast Track"
- ERAS term invented by a group of academic surgeons in London in 2001
- Started the ERAS study group
- Goal: develop the optimal pathway for perioperative care by means of literature review & adaptation of treatments to give the best fit for patient’s perioperative journey

ERAS vs. Traditional Care

Traditional patient care is not evidence-based

- Some practices contribute to adverse effects of surgical trauma
- Diffuse and time-validated clinical practices (vs. evidence), personal experience, and teaching continued tradition
- ERAS challenges long-standing and well-established perioperative management
Traditional Surgical Care

- How many of you work in facilities that practice NPO after midnight?
- Bowel preparation for colon surgery?
- NG tubes postop for colorectal surgery?
- NPO after surgery until bowel sounds return?

These are all examples of non-evidence based practices!!!

The Healthcare Landscape is Changing…

- Outcome data
- Postoperative care and recovery of the patient
- Mortality
- Post-surgical complications
- Readmission
- Patient satisfaction

Ultimately, we are talking about decreased revenue

Surgical Stress

Major surgery (any site) induces profound physiological responses
- Pain
- Nausea
- Ileus
- Increased cardiac demands
- Impaired pulmonary function

All contribute to complications….
Complications are widespread

25% post-operative complication rate

<table>
<thead>
<tr>
<th>Surgery</th>
<th>Morbidity rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esophagectomy</td>
<td>55%</td>
</tr>
<tr>
<td>Pelvic exenteration</td>
<td>45%</td>
</tr>
<tr>
<td>Pancreatectomy</td>
<td>35%</td>
</tr>
<tr>
<td>Colectomy</td>
<td>29%</td>
</tr>
<tr>
<td>Gastrectomy</td>
<td>29%</td>
</tr>
<tr>
<td>Liver resection</td>
<td>27%</td>
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</tbody>
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Major Colorectal Complications

1. Time to feed (Ileus)
2. Surgical site infection
3. Urinary infection
4. DVT
5. Myocardial infarctions
6. Stroke
7. Post-procedural delirium
8. Renal failure/AKI
9. Anastomotic leak

Bowel Resection/ Colectomy (based on 2010 MEDPAR data)

Complications are costly

$18,000 average extra cost for treating a patient developing one or more post-surgical complications, US

Added costs may include:
- Treatment (e.g., antibiotic, re-intervention, anti-coagulation)
- Lab tests
- Observation
- Investigations
- Prolonged hospital length of stay
- Increased readmissions
- Decreased patient throughput
Complications lead to readmissions

- Most significant independent risk factor for readmission
- Any postoperative complication increases the risk of readmission by a factor of four (odds ratio: 4.20; 95% CI: 2.89–6.13)

1 in 7 Medicare Pts are readmitted in 30 days


Complications affect long-term survival

- The most important determinant of decreased postoperative survival was the occurrence, within 30 days postop, of any complication
- Independent of preoperative patient risk, the occurrence of a 30-day complication reduced median patient survival by 69%


ERAS Society Guidelines

- Several versions have been published over the years for colorectal surgery
- Elective colonic surgery 1st target group
- Joint effort between ERAS Society and the International Association of for Surgical Metabolism and Nutrition (IASMEN) and the European Society for Clinical Nutrition and Metabolism (ESPEN)
ERAS Society Guidelines

- Complex review of literature related to ERAS completed by a panel of researchers
- 21 recommendations made based on the evidence—strong to weak
- Evidence level determined—high, moderate, low, very low

ERAS Research Challenges

- Lack of standardized protocols makes level of evidence low
- Poor compliance with protocols
- Much more research is needed into stress, immune and inflammatory responses after surgery, new analgesic concepts, goal-directed fluid therapy, and new drugs/substances

Preoperative optimization

- Preoperative physical conditioning (Prehab)
- At least 8 RCTs have investigated the role of Prehab on surgical outcomes
- Findings recommend:
  - Increasing exercise preoperatively
  - Smoking cessation 4 weeks preoperatively
  - Alcohol abusers stop consumption 4 weeks preoperatively

Pre-habilitation Project

- Our pilot project started January 2014
- In anticipation of full ERAS protocol
- Classes were conducted for ERAS patients preoperatively (all colorectal cases)
  - Patients given counseling by multidisciplinary team
  - Video option for distance learning
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**Why?**
- To promote healing of the surgical site
- Prevent Infections
  - At the surgical site
  - Pneumonia (breathing)
- Prevent blood clots

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**How?**
- **Good Nutrition**
  - Leads to better outcomes
  - Less risks of infection
  - Faster recovery
- **Diet**
  - High in protein
  - Lean meat (chicken, salmon etc)
**Slide 25**

**How and When?**

- **Supplements (Impact Recovery)**
  - Provided by us here today
  - Start five (5) days before your surgery
  - Three times a day
  - Prevents post surgical nausea and thirst
  - Day of Surgery Carb loading
    - Provided by us here today
    - Contains calories, protein and carbohydrates
      - Each ½ of bottle consists of 25gms of glucose
      - Drink half the bottle 8 to 10 hours before your operation
      - The other half between 2 and 3 hours before your surgery
  - **WHILE USING THESE SUPPLEMENTS**
    - AVOID EXTRA SWEETS, CARBS AND FATS IN YOUR DIET

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**Nutritional Supplement**

- IMPACT ADVANCED RECOVERY® Drink
  - Nestle Health Science
  - Contains a blend of L-arginine, omega-3 fatty acids and nucleotides to support the immune system before and after major elective surgery
  - High carbohydrate, high protein
  - Diabetics received dietician counseling for adjusting insulin/meds and diet

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**How and When?**

- **Exercise**
  - Before and After Surgery
    - Stay as active as possible
    - As soon as you know you are having surgery
    - Start a walking program
    - Walk three times a day 7 days a week
    - Increase the distance each day as you feel you can
  - Walking is one of the best ways to get your sense of well being back after an operation
How and When

- **Cholesterol medications (statins)**
  - Lower risk of heart problems for some after operations
  - We will offer you one to take seven days prior to your surgery date.

- **Mouth Care**
  - Bacteria in your mouth can drain into your lungs and cause pneumonia.
  - Brushing, flossing and using a mouthwash twice a day two weeks before surgery.
  - Immediately before surgery in the pre op area.
  - May decrease your risk of developing pneumonia.

How and When

- **Breathing Exercises**
  - Incentive Spirometry, Coughing, and Deep Breathing.
  - Spirometer (provided for you here today).
  - A device that exercises your lung.
  - Inhale deeply and slowly into the device to measure how well you are taking in air.
  - Practice using your incentive spirometer four times a day for two weeks before your surgery.

How and When

- **Stop Smoking** (or using any tobacco product)
  - Smoking is associated with several post op complications.
    - Heart problems
    - Pneumonia
    - Slow wound healing
  - While it is never too late to stop using tobacco products the sooner you stop using tobacco products prior to your surgery lowers your risks of complications.
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**How and When**

- **Bowel Prep**
  - You may be asked to do a bowel prep
  - This means cleaning out your colon before your operation
  - Will reduce the risk of infection
  - Please follow the instructions carefully and as completely as possible

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**After Surgery**

- **Mobility**
  - Get out of bed and begin moving around
  - Preserves muscle strength
  - Decreases risk of pneumonia and blood clots

- **Start your mobility**
  - By sitting on the side of the bed or in the chair
  - The evening after your surgery
  - Once your surgeon gives permission
  - Walk in the hall, initially with assistance
  - Slowly increase how far you walk and how often you walk
  - Once you are steady on your feet have your family help you with walking.

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**Blood Clot**

- **Blood Clot (Venous Thromboembolism)**
  - Occurs when your blood forms a clot inside a vein
  - Almost always occurs in the legs
  - If a clot breaks loose it may travel to the lungs
  - (Pulmonary Embolism)
  - Clots are serious and may cause death

- **To Prevent Clots**
  - Keep moving.
  - When in the bed practice exercises (we will show you)
  - Wear support hose, sequential compression devices
  - Foot pumps
  - Using incentive spirometer
  - Blood thinners
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Surgical Site Infections

- SSI (Surgical Site Infection)
- Is an infection that develops after surgery in the area of the body where you had surgery.
  - Are more common when patients
    - Smoke
    - Have diabetes
    - Or are obese
- Antibiotics
  - Given before and after surgery
  - Help prevent surgical site infections

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Surgical Site Infections

- Hair
  - Around the surgical site will be clipped using an electric razor.

- Hand washing
  - To be done by all healthcare providers
  - Also prevents infections
- Night before surgery
  - You will wash your skin with an antibacterial soap
  - You will receive at CARES
- The operating team in the Pre Op area
  - May wash your surgical site just prior to your surgery

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Pain Management

- The Goal of Pain Management
  - Control the pain
- What you can do to help manage your pain
  - Stay ahead of the pain
  - Get enough sleep
  - Increase physical activity slowly
  - Don’t sit too long
  - Brace your surgery site
  - Reduce stress
- You will still have discomfort
- When pain is controlled
  - You will be able to be more active
  - And participate in preventing complications
- You will wash your skin with an antibacterial soap
  - You will receive at CARES
- The operating team in the Pre Op area
  - May wash your surgical site just prior to your surgery
Hand washing

- Hand washing
  - Make sure everyone who enters your room washes their hands with soap and water or foam hand sanitizer.
  - Staff may use protective equipment such as gloves for safety.
  - You must remember to wash your hands while you are a patient.
  - Your family and friends should also wash their hands before coming to your bedside.
  - Is one of the best ways to prevent the spread of infection.

Preventing Falls

- Your safety is important to the healthcare team.

- You will be evaluated for your risk of falling.
  - If you are a high risk
    - The nurse will place a yellow armband on your wrist.
    - After surgery you may receive medicines that may cause you to be unsteady.

- You can reduce your risk of falls by doing the following:
  - Ask for help getting up for the first time.
  - Use your call bell.
  - Sit on the side of the bed for a few minutes before you stand.
  - Wear non-skid slippers and move slowly.
  - Keep call bell in reach.
  - Work close to the wall and use handrails for safety.
  - DO NOT lean on equipment with wheels (IV poles).
  - Wear your glasses or hearing aids.
  - Pull the emergency cord in the bathroom if you need assistance.
  - Tell your nurse if you use a walker, cane, wheelchair or bedside commode at home.
Next Steps

- Keep Your Pre-Surgical Testing appointment
- Review
  - Packet of Pre Surgery and Post Surgery Instructions
- Keep
  - Log of exercise, spirometer, supplements and tooth brushing
- Questions or concerns about this class
  - Ask your surgeon
  - Call 540-266-6383

Morning of Surgery

- You will come to the 4 North entrance
- Check in
- Family phone numbers obtained
- Tracking number
  - Your family will be able to tell where you are in your surgical process
  - Pre op
  - Surgery
  - Post Op

ERAS Implementation

- Phased implementation
- Educate, educate, educate
- Started with small group of surgeons
- Followed the ERAS Society recommendations with some additions
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**ERAS Recommendations**

**Preadmission information, education, and counseling**
- Pts should routinely receive dedicated preoperative counseling

**Preoperative optimization**
- Increasing exercise preoperatively may be of benefit
- Cease smoking 4 weeks preop
- Alcohol abusers should cease ETOH consumption preop

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**ERAS Recommendations**

**Preoperative bowel preparation**
- Elective colonic resection above the peritoneal reflection should not receive routine oral bowel prep (grade A)
- Consider bowel prep in low resection cases when diverting stoma is planned

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**ERAS Recommendations**

**Preoperative fasting and carbohydrate treatment**
- Allow clear fluids up to 2 h and solids up to 6 h prior to induction of anesthesia
- Pt with delayed gastric emptying may need safety measure at induction of anes.
- Preop oral carbohydrate treatment should be used routinely; diabetics can receive with their diabetic medication

**Preanesthetic medication**
- Pts should not receive medications for long-term sedation
- Short-acting medications for preop procedures are acceptable (grade A)
**Thromboembolism Prophylaxis**
- SubQ low-dose unfractionated heparin or subQ LMW heparin are preferred (grade A) - 28 days for pts with colon cancer
- Pts should wear well-fitting compression stockings, have intermittent pneumatic compression

**Antimicrobial prophylaxis and skin preparation**
- Pts undergoing colorectal resection should receive single-dose prophylaxis against anaerobes and aerobes 1 hour preop (grade A)
- Chlorhexidine-based skin solution preferred; clipping of hair vs. shaving

**Standard Anesthetic Protocol**
- Avoid long-acting opioids
- Mid-thoracic epidural analgesia commenced preoperatively – LA and low-dose opioid combination (grade A)

**Preventing and treating PONV**
- Prevention should be used with any patient with 2 or more risk factors; treatment should be immediate

**Laparoscopic-assisted surgery**
- Laparoscopic technique is recommended if the surgeon and department is proficient with the technique & outcomes are validated against open (grade A)

**Surgical Incisions**
- Midline or transverse laparotomy incision of minimal length should be used for elective colorectal surgery

**Nasogastric Intubation**
- Nasogastric tubes should not be used routinely in postoperative period
- Only place postoperatively for illness

**Preventing intraoperative hypothermia**
- Intraoperative maintenance of normothermia with an upper-body forced-air heating blanket should be used routinely (grade A)
ERAS Recommendations

**Intra- and post-operative fluid restriction in major colonic surgery with avoidance of hypovolemia is safe (grade A)**

**Normovolemia leads to better outcomes (grade A)**

**Intraoperative goal-directed therapy is superior to non-protocol based standard with respect to outcomes (grade A)**

**Use of esophageal doppler or minimally invasive cardiac output monitors can guide fluid replacement**

**Convert to enteral route for fluid replacement asap post-surgery**

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**ERAS Recommendations**

**Drains are not indicated following routine colonic resection above the peritoneal reflection (grade A)**

**Short-term (24hr) use of drains after low anterior resection may be advisable**

**Suprapubic urinary drainage for pelvic surgery is recommended (grade A)**

**For colonic surgery, suprapubic or urethral techniques (<2 days) are appropriate**

**Midthoracic epidural analgesia and avoidance of fluid overload are recommended to prevent ileus (grade A)**

**Laparoscopic approach is recommended (grade A)**

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**ERAS Recommendations**

**Pts should receive continuous midthoracic (T-8/10) epidural low-dose LA and opioid combinations (grade A) for approximately 48-72 h following elective open colonic surgery**

**Laparoscopic pts may receive intrathecal low dose, long acting opioid**

**Acetaminophen should be used as a baseline analgesic (grade A) throughout the postoperative course**

**Epidural boluses for breakthrough pain**

**NSAIDs should be started when epidural is removed**
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**ERAS Recommendations**

- Patients should commence oral diet at will postop (grade A)
- Oral nutrition supplements should be prescribed from day of surgery until normal diet is achieved, and continued for weeks in malnourished patients (grade A)
- Avoid hyperglycemia
- Perioperative nutritional care/glucose control
- Patients should be encouraged to ambulate
- Care plan to get pts out of bed for 2 h DOS and 6 h thereafter
- A systematic audit should be performed to measure outcomes of ERAS
- ERAS protocols should be used in elective colonic surgery

**Audit**

- Nurses
- Nurses
- Multi-disciplinary

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**Our Preop Protocol-Details/Additions**

- Laparoscopic cases receive Entereg (alvimopan) in preop
- SCDs placed on patient and turned on
- Prewarming with Bair Paws® gowns
- Oral care with CHG
- Clear, high carbohydrate drink 2 hrs preop (3 hrs if delayed gastric emptying)

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**Entereg (alvimopan)**

- Patients receive Entereg 12 mg PO in the preop holding area; followed by 12 mg PO BID until first bowel movement or dc
- Entereg selectively binds to μ-opioid receptors in the GI tract, competing with opioids; prevents opioids from impairing GI function
- Does not impact efficacy of opioid pain control
- Short term, inpatient use only
- Maximum 15 doses
- Contraindicated in complete bowel obstruction
Enterig is indicated to accelerate the time to upper and lower GI recovery following partial bowel resection with primary anastomosis.

**Our Intraop Protocol Details/Additions**

- Use of wound protector in open case or in extraction site for laparoscopy
- 80% inspired oxygen intraop and through PACU

**PONV prophylaxis**

- 2 drug combination, before end of case:
  - ondansetron 4mg IV
  - promethazine 12.5 mg IV (6.25 mg if over age 65y)

- Dexamethasone IV at provider discretion
Multimodal Analgesia

Acute pain, particularly postoperative pain, may be complex, multifactorial, and therefore optimally treated via a multimodal analgesic approach. 2 or more analgesics acting by different mechanisms are administered:
- Opioids, regional anesthesia, NSAIDs, COX-2 inhibitors, acetaminophen, local anesthetics, etc.

Our Pain Management Protocol

- Open cases: mid-thoracic epidural (T-8/10)
- Placed in the preop holding area
- Combination low-dose LA and opioid infusion with bolus PCA
- If patient refuses or is not a candidate, follow laparoscopic guidelines

Our Pain Management Protocol

- Laparoscopic cases: Intrathecal PF morphine sulfate preop and/or IV lidocaine infusion
- Limit additional intraop narcotics, avoid N2O, limited inhalation agents
- Administration of non-narcotic analgesics
**Epidural Management Issues**

- Heparin 5000 units SQ BID started night of surgery
- Patient receives 2 doses, then next night dose is held
- On POD 2, patient’s epidural is pulled @ 0800
- Heparin restarted 2 hrs after removal

**Respiratory Depression**

- ASA closed claims project identified respiratory depression in 15 cases PCA, 16 cases neuraxial opioids
- Event in 1st 24h in 50% cases
- 60% patients died, 13% permanent brain injury
- Supplemental O2 makes pulse oximetry poor monitor (40%FiO2 - CO2 150mmHg - SaO2 100%)

**Respiratory Depression**

- Identify patients at risk prior to neuraxial opioids
- History of OSA, coexisting diseases, medications (other opioids/sedatives)
- Careful selection of neuraxial opioid-drug, dose, delivery
- Single injection neuraxial opioid up to 3% incidence of respiratory depression
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Respiratory Depression

- Detection of respiratory depression requires monitoring (resp rate, sedation, pain, O2 sat)
  - Hourly X 12 hrs
  - Q 2 hrs for next 12 hrs
  - Q 4 hrs until infusion discontinues (we do Q 2 hrs)
  - Minimum of 24 hrs for morphine/hydromorphone, 2 hours with fentanyl

ASA Task Force on Respiratory Depression following neuraxial opioids
Horlocker, Anesthesiology, 2009

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Ofirmev

- Ofirmev (acetaminophen)
  - 1 gram IV intraprop
  - Continue 1 gm IV q 6 hrs X 24 hrs; then
  - Acetaminophen 650mg PO q 6 hrs X 24 hrs

**Avoid in patients with severe hepatic impairment or severe active liver disease**

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NSAIDs

- Ketorolac, 30 mg IV, or 15 mg IV (if over age 65 or compromised renal function) before end of case
  - Continued q 6 hr X 48 hr at same dose

Ketorolac 30mg IV is equivalent to morphine sulfate 10 mg IV
Intravenous Lidocaine

- ERAS patients may receive an IV lidocaine infusion to help control postop pain
- Started intraop at 2mg/min (2g/500ml @30ml/hr)
- Continued for 24 hours
- Avoid in patients with current or history of cardiac arrhythmias

Our post-op protocol

- Oral clear liquids (non-carbonated) as soon as patient will tolerate
- Diet advanced as tolerated
- IVFs limited to 40-60 ml/hr
- IV fluid bolus only for symptomatic hypotension or tachycardia
- Impact® supplements added as soon as PO intake tolerated

Reduced Length of Hospital Stay in Colorectal Surgery after Implementation of an Enhanced Recovery Protocol

Perioperative Goal- Directed Therapy (PGDT)

The standard for the future??

The Pathogenesis of Complications

Cardiac output 4-8 l/min

<table>
<thead>
<tr>
<th>Organ</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain</td>
<td>14</td>
</tr>
<tr>
<td>Heart (Coronary Circulation)</td>
<td>3</td>
</tr>
<tr>
<td>Liver</td>
<td>6</td>
</tr>
<tr>
<td>Gastrointestinal System/Spleen</td>
<td>25</td>
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<tr>
<td>Kidney</td>
<td>22</td>
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<tr>
<td>Musculoskeletal</td>
<td>25</td>
</tr>
<tr>
<td>Skin</td>
<td>6</td>
</tr>
<tr>
<td>Bone, Other</td>
<td>8</td>
</tr>
</tbody>
</table>
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Traditional fluid monitoring is inadequate.

Impact on Gut perfusion at 10-15% EBL.

25-30% EBL

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Oxygen Delivery (DO₂) = Cardiac Output (CO) x Arterial Oxygen Content (CaO₂)

Cardiac Output (CO) = Stroke Volume (SV) x Heart Rate (HR)

Arterial Oxygen Content (CaO₂) = (1.38 gms Hgb x SaO₂) + PaO₂ x 0.0031

Hemoglobin
SaO₂
Arterial Oxygen Saturation
PaO₂
Arterial Oxygen Tension

Preload
Afterload
Contractility

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Fluid imbalance leads to complications.

Volume Load

Hypovolemic
Optimal
Edematous
Hypoperfusion
Organ dysfunction
Adverse outcome
Edema
Organ dysfunction
Adverse outcome

Hypovolemic
Optimal
Edematous

Volume Load

OPTIMAL
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Evolution of Volume Management

The "Conventional" approach is trying to predict the amount of volume / fluids needed based upon the duration and severity of a particular procedure.

The "Intensive" fluid approach is based on minimizing fluids based on Blood Pressure

The "Perioperative Goal Directed Therapy" approach considers optimizing volume / fluids via the Frank-Starling Curve and individualizing to goals.

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PGDT reduces complications and LOS

<table>
<thead>
<tr>
<th>Complication Type</th>
<th>Odd Ratio (CI)</th>
<th>PGDT vs. Standard Fluid Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonia</td>
<td>1.16 (0.43-1.89)</td>
<td>PGDT vs. Standard Fluid Management</td>
</tr>
<tr>
<td>Sepsis</td>
<td>1.95 (0.57-0.90)</td>
<td>PGDT vs. Standard Fluid Management</td>
</tr>
<tr>
<td>Hospital length of stay</td>
<td>1.16 (0.43-1.89)</td>
<td>PGDT vs. Standard Fluid Management</td>
</tr>
<tr>
<td>ICU length of stay</td>
<td>1.95 (0.57-0.90)</td>
<td>PGDT vs. Standard Fluid Management</td>
</tr>
</tbody>
</table>

Reference:


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Major Abdominal Surgery
Impact on Morbidity

In Benes, trial complications were reduced by 56%
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**Great Truth of Hemodynamic Monitoring**

No monitoring device can improve patient-centered outcomes unless it is coupled to a treatment that improves outcome.

Thus, hemodynamic monitoring must be considered within the context of proven medical therapies, success of which is dependent on the clinical condition, pathophysiological state, and ability to reverse the identified disease process.

- M. Pinsky, J.L. Vincent

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**Meta-Analysis: Review on use of GDT**

Brienza 2009

- This systematic review and meta-analysis of 20 randomized controlled trials included 4,220 patients.
- Perioperative hemodynamic optimization was associated with reductions in:
  - Incidence of postoperative acute renal injury (AKI) (odds ratio [OR] 0.64; p = 0.0007)
  - AKI risk (OR 0.66; p = 0.004)
  - Mortality (OR 0.50; p = 0.004), but statistical heterogeneity was observed.
- The occurrence of renal dysfunction was reduced when treatment started both preoperatively and intraoperatively or postoperatively, was performed in high-risk patients, and was obtained by fluids and inotropes.

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**Meta-Analysis: Review on use of GDT**

Giglio 2009

- This systematic review and meta-analysis of 16 randomized controlled trials included 3,410 patients.
- GDT was associated with reduced incidence of:
  - Major GI complications (pooled odds ratio [OR] 0.42)
  - Minor GI complications (OR 0.29)
- Treatment did not reduce hepatic injury rate (OR 0.54).
This systematic review and meta-analysis of 26 randomized controlled trials included a total of 4,188 patients.

- Perioperative goal-directed therapy patients experienced:
  - 37% reduction in surgical site infections (P < 0.0001)
  - 25% reduction in pneumonia (P = 0.009)
  - 59% reduction in urinary tract infections (P = 0.02)

- A significant benefit was also found regarding total infectious episodes (P < 0.00001)

This systematic review and meta-analysis of 29 randomized controlled trials included a total of 4,805 patients.

- Preemptive hemodynamic intervention significantly reduced:
  - mortality (pooled odds ratio [OR] of 0.48; P<0.0002)
  - surgical complications (OR 0.43; P<0.0001)

- Subgroup analysis showed significant reductions in mortality for studies using:
  - pulmonary artery catheters
  - resuscitation targets
  - fluids and inotropes as opposed to fluids alone

- By contrast, there was a significant reduction in morbidity for each of the 4 subgroups analyzed.

This systematic review and meta-analysis of 23 randomized controlled trials included 3,861 patients. The following therapies were assessed: (a) goal-directed therapy, (b) restrictive fluid therapy, and (c) liberal fluid therapy. Both liberal and GDT used more fluid compared to their respective comparative arm, but their effects on outcomes were very different.

- Compared to those in the restrictive group, patients in the liberal fluid therapy stratum had:
  - higher risk of pneumonia (relative risk [RR] 2.2)
  - higher risk of respiratory failure (RR 3.6)
  - longer hospital LOS (mean difference [MD] 2 days)
  - longer time to first bowel movement (MD 2 days, p<0.04)

- GDT resulted in:
  - lower risk of pneumonia (RR 0.7)
  - lower risk of renal complications (RR 0.7)
  - shorter hospital LOS (MD 2 days)
Two Goal-Directed Protocol Philosophies

SV Max (Fluid First)
Give fluid, observe response, continue to give fluid and other therapies until target achieved

Hemodynamic Stability (Observe First)
Measure deterioration of clinical condition, titrate therapy using a variety of parameters

Variations:
• Different "trigger" parameters: SVV, CO/CI, DO2, SvO2/ScvO2, CVP (declining)
• Different philosophies on degree of treatment

Efficacy of CVP Monitoring

Does the Central Venous Pressure Predict Fluid Responsiveness? An Updated Meta-Analysis and a Plea for Some Common Sense*
Paul E. Marik, MD, FCCM1; Rodrigo Cavallazzi, MD2

Meta-analysis incorporating 43 recent studies that investigated indices predictive of fluid responsiveness

Subgroup analysis of
• ICU vs. OR, cardiac vs. non-cardiac
• surgery patients, mechanical vent

Conclusion: CVP is unable to predict fluid responsiveness in a wide range of patients

SVV – Stroke Volume Variation

Positive pressure ventilation impairs both the return of blood to the heart, and the ejection of blood through the pulmonary circulation

In positive pressure ventilated patients, the decrease in preload from mechanical inspiration = decrease in stretch = decrease in stroke volume

We can use SVV as a predictor of fluid volume status
Effects of a positive pressure breath on the central veins and right cardiac chambers

Effects of positive pressure on the pulmonary circulation and the left cardiac chambers

SVV Measurement

SVV can be invasively or non-invasively measured.
Typical SV-Max Protocol

Monitor SV

200 ml colloid over 10 minutes

SV increase > 15%

Yes

SV decrease > 15%

Yes

Monitor SV

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Randomized controlled trial investigating the influence of intravenous fluid resuscitation using esophageal Doppler monitoring during bowel surgery

Conway 2002

57 major bowel surgery patients were randomized to control or esophageal Doppler-guided fluid challenge groups

- GDT group:
  - Experienced increased stroke volume, corrected filling time and cardiac output (P<0.05)
  - Did not require critical care (P=0.02)

- Hospital LOS and time to tolerate oral diet was similar between the groups (no p-value referenced)

SV-Max Protocol

Gan 2002

- 100 mixed general, gynecological and urological surgery patients were randomized to a control or Doppler-guided intraoperative plasma volume expansion group

- GDT group experienced:
  - Higher stroke volume and cardiac output at the end of surgery (P<0.05)
  - Shorter hospital LOS (2.8 vs 4.9 days; P=0.05)
  - Earlier tolerance of oral intake (2.5-3.5 vs 4.2-5.2 days; P<0.01)
  - 61% reduction of severe nausea and vomiting requiring rescue anti-emetic treatment (P<0.05)
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128 major bowel surgery patients were randomized to a conventional or Doppler-guided intraoperative fluid management group.

- GDT group experienced:
  - 14% reduction in median time to tolerating full diet (P<0.001)
  - 13% reduction in median postoperative hospital LOS (P<0.05)
  - 69% reduction in number of patients who suffered gastrointestinal morbidity (P<0.001)
  - lower overall morbidity (P=0.05)

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108 elective colon resection patients were randomized to a control or Doppler-guided fluid challenge group.

- GDT group experienced:
  - higher aortic flow time, stroke volume, cardiac output and cardiac index during the intraoperative period (P<0.05)
  - 22% reduction in postoperative hospital LOS (P=0.005)
  - 87% reduction in intermediate or major postoperative complications (P=0.043)
  - 50% reduction in time to tolerate diet (P=0.029)
  - reduced rise in perioperative level of the cytokine interleukin 6 (P=0.039)

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162 severe multiple trauma patients were randomized to a control or Doppler-guided fluid resuscitation group.

- GDT group experienced:
  - lower blood lactate levels 12 and 24 after treatment (2.38-3.46 vs 2.69-3.77; P<0.0003 and 1.55-2.43 vs 1.79-2.95mm/l; P<0.0001, respectively)
  - 45% reduction in number of patients who developed infectious complications (P=0.002)
  - 18% reduction in median ICU LOS (P=0.001)
  - 20% reduction in hospital LOS (P=0.046)
179 colorectal surgery patients (123 aerobically fit, 56 aerobically unfit) were randomized to a standard fluid regimen or esophageal Doppler-guided intraoperative GDT group.

Intraoperative SV optimization conferred no additional benefit over standard fluid therapy with respect to surgical readiness for discharge or LOS (P=0.09).

Furthermore, in a subset of lower risk patients with no cardiopulmonary comorbidity, GDT caused delayed discharge and increased admission to critical care (P=0.01).

- **Hemodynamic Stability Protocols**

  - **SV-Max Protocol**

  - **Hemodynamic Stability: Pinsky Protocol**

  - Is the patient hemodynamically stable?
    - Yes
    - No
  
  - Is the patient preload-responsive?
    - Yes
    - No
  
  - Is the patient hypotensive and have reduced vasomotor tone?
    - Yes
    - No
  
  - Volume bolus
  
  - Add Vasopressor
  
  - Add Inotrope
  
  - Reassess the patient
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Hemodynamic Stability: $\text{DO}_2$

- 122 high-risk surgical patients were randomized to a control or LiDCO plus-guided GDT group.
- GDT group experienced:
  - 35% reduction in number of patients who developed complications ($P=0.003$)
  - Fewer complications per patient (0.7 SD±0.9 vs. 1.5 SD±1.5; $P=0.002$)
  - 21% reduction in median hospital LOS ($P=0.001$)

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Hemodynamic Stability: ScvO$_2$/O$_2$ERe

- 135 high-risk major abdominal surgery patients were randomized into a control or central venous catheter-guided protocol group.
- GDT group experienced:
  - 60% reduction in number of patients who had at least one organ failure ($p<0.05$)
  - 67% fewer total number of organ failures ($p<0.001$)
  - 16% reduction in hospital LOS ($p<0.05$)

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Hemodynamic Stability: PPV

- 33 high-risk abdominal surgery patients were randomized into a control or arterial pressure transducer-guided protocol group.
- GDT group experienced:
  - 59% reduction in postoperative hospital LOS ($P<0.01$)
  - Fewer postoperative complications per patient (1.4±2.1 vs. 3.9±2.8; $P<0.05$)
  - 80% reduction in median duration of mechanical ventilation ($P<0.05$)
  - 67% reduction in ICU LOS ($P<0.01$)
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**Hemodynamic Stability: SVV**

- 120 high-risk abdominal surgery patients were randomized to a control or Vigileo/FloTrac-guided fluid management group.
- GDT group experienced:
  - 43% fewer hypotensive events (P=0.0001)
  - Lower lactate levels at the end of surgery (1.78 ± 0.96 vs. 2.26 ± 1.1 mmol/l; P=0.0252)
  - 46% reduction in number of patients who developed complications (P=0.0032)
  - 56% reduction in overall number of complications (P=0.0062)
- A difference in hospital LOS was found only in per protocol analysis of patients receiving optimization (9 vs. 10 days; P=0.0421)
- No difference was found in mortality or ICU LOS (P-values: 1.0; 0.789, respectively)

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**Hemodynamic Stability: CI/MAP**

- 40 elective major abdominal surgery patients with pre-existing cardiac disease were randomized into a control or Vigileo/FloTrac-guided protocol group.
- GDT group experienced:
  - Lower plasma NT-proBNP levels on postoperative days 1 and 2 (832 ± 675 vs. 1633 ± 690 and 1097 ± 827 vs. 2085 ± 871 pg/mL; P=0.009)
  - Shorter hospital LOS (14.8 ± 4.7 vs. 20.6 ± 8.1 days; P=0.009)
- Note: Although this paper and protocol withstanded criticism and were never retracted, one of the authors (Joachim Boldt) was found guilty of academic dishonesty on several of his other papers.

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**Hemodynamic Stability: SVV**

- 38 high-risk abdominal surgery patients were randomized to standard or Vigileo/FloTrac-guided protocol group.
- GDT group experienced:
  - Earlier return of GI function (3 vs 4 days; P=0.004)
  - Earlier return of PO intake (4 vs 5 days; P=0.004)
  - 33% decrease in hospital LOS (p=0.04)
  - Higher quality of recovery scores on postoperative days 2 and 4 (p-values =0.05 and 0.03, respectively)
Hemodynamic Stability: SVV

Ping 2012

5%-7%

- 40 elective gastrointestinal surgery patients were randomized into Vigileo/FloTrac-guided routine (SVV maintained between 5-7%) or restricted (SVV maintained between 11-13%) fluid administration groups.

- A fluid loading goal directed therapy with a restricted objective showed:
  - 19% reduction in hospital LOS (P<0.01)
  - 16% faster recovery time to normal diet (P<0.05)

Hybrid: SV Maximization and Hemodynamic Stability Protocols

Jhanji 2010

Hybrid: SV Max and DPX

Group Goal
CVP CVP > 2 mmHg
SV SV > 10%
SV & DPX

- Additionally, a continuous intravenous infusion of dopexamine was administered at 0.5 mcg/kg/min.

- 135 high risk surgery patients were randomized into three intravenous fluid therapy groups guided by: (a) central venous pressure, (b) stroke volume, or (c) stroke volume and dopexamine.

- SV-guided fluid and low dose inotropic therapy was associated with improved:
  - Global oxygen delivery (P < 0.05)
  - Microvascular flow (P < 0.005)

- SV and SV/DPX groups experienced 64% fewer incidents of acute kidney injury relative to CVP group (P = 0.03).

- There were no differences in overall complication rates between the groups.
• Systematic literature review revealed 3 goals to guide haemodynamic therapy in noncardiac surgery: optimization of SV by fluid therapy; maintenance of a target MAP by vasopressor treatment; and target CI of ≥ 2.5 l/min per m² to avoid a low CO state.

• 774 noncardiac surgery cases were identified - 8% were suitable to be treated according to the goal directed hemodynamic algorithm.

• GDT group experienced:
  - Reduction in length of hospital stay (mean SD 17.7 9.2 vs 25.9 25.8 days; P = 0.027)
  - 74% reduction in number of patients requiring postoperative ventilator therapy (P = 0.004)
  - 76% reduction in number of patients requiring prolonged hospital stays (P = 0.023)

Donati protocol

\[ \text{SaO}_2 - \text{ScvO}_2 = \text{O}_2\text{ER} \]

- CVP > 10 cm H2O
- Or < 12% SVV
- Fluid Challenge - Colloids (Hg > 10 g/dl) - PDC (Hg < 10 g/dl)

- Dobutamine Targets - CVP and Oxygen Extraction ratio

UK-NICE and SFAR Protocol

- Monitor SV
- 200 ml fluid over 5 minutes
- SV increase > 10% YES
- SV decrease > 10% NO
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Benes Protocol

Measure and Record SVV, CI

Repeat monitoring of SVV, CI during next 5 minutes

SVV > 10% and CVP < 15 mmHg

Colloid bolus 3 ml/kg over 5 minutes

Dobutamine infusion to reach CI > 2.5 l/min/m²

SVV > 10% or Increase of CI > 10%

YES

NO

CVP rise < 3 mmHg

CI < 2.5 l/min/m²

SVV < 10% and No change or decrease of CI

CVP, SVV, and CI

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ERAS Care System

The ERAS Care System has three parts:

ERAS Protocol - an evidence-based care protocol developed by the ERAS Society.

ERAS Implementation Program - a change management program specifically developed for the perioperative team of surgical clinics performing major operations.

ERAS Interactive Audit System - a software program designed to ensure compliance to the protocol, analyze real-time control of patient information at every step, and monitor the results. It is used by both the health care staff as well as administration.

http://www.erassociety.org/index.php/eras-care-system/general-overview