MILESTONES IN THE DEVELOPMENT OF INTESTINAL ANASTOMOSES

BRIAN SADOWSKI, MD, FACS, FASCRS
ASSISTANT CLINICAL PROFESSOR
CREIGHTON UNIVERSITY SCHOOL OF MEDICINE
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DISCLOSURES

• NONE
LEARNING OBJECTIVES

• DISCUSS THE HISTORY OF INTESTINAL ANASTOMOSES AND TECHNICAL IMPROVEMENTS OVER TIME
• UNDERSTAND AND DESCRIBE TECHNICAL ASPECTS OF CONSTRUCTING IDEAL INTESTINAL ANASTOMOSES
• DISCUSS IMPROVED OUTCOMES AS THEY RELATE TO IMPROVED TECHNIQUES

ANASTOMOSIS?

• "ANASTOMOSIS" = UNION OF PARTS SO AS TO INTERCONNECT
  • FROM GREEK "ANASTOMOUN" = TO PROVIDE WITH AN OUTLET, TO FURNISH WITH A MOUTH

• FOR US, THIS WILL REFER TO CONNECTING TWO SECTIONS OF BOWEL FOR THE PURPOSE OF RECREATING INTESTINAL CONTINUITY
HISTORY OF THIS GOES WAY BACK!

- INDIAN SUSHRUTA, 600 BC
  - Writings refer to operations for many pathologies, including "laparotomy and management of intestinal obstruction, as well as treatment of perforated intestines"
- HIPPOCRATES SET US UP TO FAIL—400 BC "If any portion of the small intestines be cut through, the extremities do not reunite"
- CELSUS 25 AD. "The larger intestine can be sutured, not with any great assurance, but because a doubtful hope is preferable to certain despair, for occasionally it heals up"

SLOW PROGRESS IN WESTERN CIVILIZATION

- 900S—AL-ZAHRAWI: FIRST SUTURELESS ANASTOMOSIS—Employ large black ants, closure of jaws coapt edges, decapitate ants and jaws remain closed
- RUGGERIO DEI FRUGARDI IN 1100S—REPAIRED TRAUMATIC BOWEL INJURY WITH A STENT MADE OF ANIMAL TRACHEA
- ANASTOMOSES LARGELY ABANDONED UNTIL 19TH CENTURY (EXCEPT FOR TRAUMA).
A BIG LEAP INTO THE 19TH CENTURY...

• ELECTIVE INTESTINAL ANASTOMOSES ARE A RECENT ADVANCE:
  • SCIENCE OF THE 1800s:
    • 1810—DUPUYTREN DESCRIBES DIFFERENCES OF BOWEL WALL LAYERS. SHOWS THAT THE SEROSA HAS RAPID INFLAMMATORY ADHERENCE (POSTOPERATIVE ADHESIONS?)
    • 1821—JOBERT DESCRIBES SEROSA TO SEROSA APPOSITION AND BOWEL REPAIR WITH UPPER END OF INTESTINE BEING INVAGINATED INTO THE LOWER
    • 1812—TRAVERS STUDIED ANASTOMOTIC TECHNics TO SEROSA APPOSITION: “THE UNION OF A DIVID THE ENTIRE CIRCUMFERENCE…THE SPECIES OF SUT IMPORTANCE”. (STILL TRUE?)

“Inquiry of the Causes and Nature of the Injuries of the Intestines, and their Treatment by Surgical Means and by Antiseptic Appliances”
MORE PROGRESS...

- 1823—FIRST ELECTIVE (SIGMOID) COLON RESECTION WITH ANASTOMOSIS BY REYBAR IN FRANCE. HIGHLY CRITICIZED.
  - SLOW TO CATCH ON: BY 1880 ONLY 10 REPORTED, WITH 70% MORTALITY
- 1826—LEMBERT'S “MEMOIRES SUR L'ENTERORRAPHIE” DESCRIBES IMBRICATING SEROSA TO SEROSA APPPOSITION. APPLIED TO LONGITUDINAL AND TRANSVERSE INCISIONS. USED CADAVER STUDIES
- 1841—CRUVEHIER: FRENCH ANATOMIST DESCRIBES SUBMUCOSA, THE "FIBRO LAMELLA"
- 1846—WILLIAM TG MORTON: FIRST ETHER GENERAL ANESTHETIC
- 1865—LISTER: ADVANCES ANTISEPSIS WITH CARBOLIC ACID
- 1884—CHAMBERLAND HELPS DEVELOP AUTOCLAVE/STEAM STERILIZATION
- 1890—HALSTED: INTRODUCES RUBBER GLOVES

GET ME OUT OF THE 1800S!

- 1880—CZERNY APPROXIMATED SEROSA TO MUCOSA IN TWO LAYERS
- 1880—KOCHER DESCRIBED TWO-LAYER SUTURE AND STRESSED THE IMPORTANCE OF GOOD BLOOD SUPPLY TO ENDS
- LATE 1800S—HALSTED REEMPHASIZED THE IMPORTANCE OF SUBMUCOSA. DESCRIBED QUILT SUTURE.
CHANGES IN TECHNIQUE

- Inversion was serosa to serosa apposition—standard of care until 1950s
- 1952 JH Hertzler and WM Tuttle—first to use deliberate eversion. Did animal studies
- 1966 Getzen, Roe, and Holloway described single layer everted suture; did studies in large and small bowel models
- 1970–Goligher did first prospective RCT inverting vs evverting anastomoses. 70 pts with colonic anastomosis compared inverting double layer vs evverting single layer. Inverting patients had significantly decreased fecal fistula rate and decreased wound infection rate

A MODERN SUTURED ANASTOMOSIS
MODERN "SUTURELESS" ANASTOMOSES

• 1826 DENANS OF MARSEILLES USED RING STENT WITH A CENTRAL STEEL SPRING. ALLOWED FOR SEROSA TO SEROSA APPPOSITION

• OTHER ADJUNCTS:
  • CATGUT RINGS OF ABBE'
  • BONE PLATES OF SENN
  • DECALCIFIED BONE BOBBIN OF MAYO-ROBSON
  • INFLATABLE RUBBER CYLINDER OF HALSTED
  • BOBBIN OF RAW POTATO OR CARROT
  • SEGMENTED ALUMINUM RING OF HARRINGTON

BUTTONS, RINGS, ETC

• JOHN BENJAMIN MURPHY INVENTS THE "SUTURELESS COMPRESSION ANASTOMOTIC DEVICE" THAT COLLOQUIALLY BECAME KNOWN AS THE "MURPHY BUTTON".
• 1892 MURPHY BUTTON WAS THE PREFERRED METHOD OF CREATING ANASTOMOSES FOR 20 YEARS. DRAWBACKS WERE STENOSIS, SCARRING, AND LUMINAL BLOCKAGE
• 1985 HARDY DEVELOPED THE "VALTRAC" BIOFRAGMENTABLE ANASTOMOTIC RING (VALTRAC). NOT A PRESSURE NECROSIS PHENOMENON, BUT RATHER BODY'S FLUIDS AT ~DAY 14 AFFECTED THE DEVICE MATERIAL AND CAUSED IT TO PASS. NOT SUCCESSFUL
NEWER COMPRESSION DEVICES

• COLON RING COMPRESSION ANASTOMOSIS 2011/2012
• MULTIPLE STUDIES WITH LEAK RATES 1-4%
• LOTS OF POSITIVE PUBLICATIONS, AND THEN IT DISAPPEARS
• TURNING LEMONS INTO LEMONADE?
• MAGNETIC RING COMPRESSION ANASTOMOSIS IS NEWEST PLAYER; FIRST CLINICAL TRIAL REPORTS IN 2017
JUST GLUE IT BACK TOGETHER!

- Glues primarily used as an adjunct
  - Primary method with 33% failure rate
  - First described by Heronimus Braunschweig in 1497
  - Buttress for suture anastomosis in 1950s—trials
- Biological glues improved with time
  - Better sterility, stability at body temperature, stability in aqueous environment, minimal immunologic reactivity, suitable longevity
  - Fibrin glue in 1970s-1980s
  - Again, best used as adjunct

20TH CENTURY BRINGS US STAPLERS!

- 1908 Humer Hultl created first stapling device. Expensive, 2 hrs to assemble, 5 kg, fired four rows of B-shaped staples, sold 50
- 1924 Alder Petz improved on Hultl; created a device made from a payer's clamp and put two rows of staples into it—1 kg, cheaper, sold a lot, single use
- 1936 Sander—staples driven simultaneously
- 1934 H. Friedrich developed a replaceable cartridge, so the device could be fired multiple times in one case; also had ability to adjust compression
- 1954 Nakayama used pliers to drive the staples
MOST OF THINK "RUSSIA" WHEN WE THINK STAPLERS

- MID-1900S—SOVIET MINISTRY OF HEALTH ESTABLISHED THE SCIENTIFIC RESEARCH INSTITUTE FOR EXPERIMENTAL SURGICAL APPARATUS AND INSTRUMENTS
- NOT ENOUGH TRAINED SURGEONS TO DO RESECTION/ANASTOMOSES FAR OUT FROM CAPITAL CITIES.
- STAPLERS WERE HAND MADE, PARTS NOT INTERCHANGEABLE, DIFFICULT TO CLEAN

1958 MARK RAVITCH WENT TO RUSSIA TO OBSERVE USE OF BRONCHIAL STAPLER, BROUGHT BACK THEIR TECHNOLOGY, AND IMPROVED IT.

- RAVITCH WORKED WITH FELICIEN STEICHEN AND LEON HIRSCH (FUTURE FOUNDER OF US SURGICAL) TO DEVELOP TA, GIA (PROTOTYPES BY 1964), AND EEA (1979)

TA AND GIA STAPLERS

- BAKA CLAMP AND UKB-40 DEVELOPED FOR GI RESECTIONS (TA PREDECESSOR)
- NZHKA WAS RUSSIAN PRECURSOR TO GIA STAPLER
LAPAROSCOPY HAS PUSHED TECHNOLOGY... OR VICE VERSA?

EEA DEVELOPED IN LATE 1970S

RUSSIAN PREDECESSORS PKS-25, SPTU, KTS-28

PLACED SINGLE ROW OF CIRCULAR STAPLES, UNRELIABLE

ALWAYS REQUIRED REINFORCEMENT WITH MANUAL SUTURES (USELESS IN PELVIS)

RAVITCH IMPROVES IT BY MODIFYING TO TWO ROWS OF OFFSET STAPLES

THE EEA CREATES AN END TO END, INVERTED ANASTOMOSIS

REPRODUCES ANATOMIC FEATURES OF TRADITIONAL HAND SEWN ANASTOMOSIS

SIGNIFICANTLY REDUCED ANASTOMOSTIC LEAKS IN ESOPHAGEAL AND RECTAL

ONCE PERFECTED, ALLOWS FOR ANASTOMOSIS LOW IN PELVIS (OPEN AND LAP EASIER)
SO WHERE DOES ALL THIS PROGRESS LEAVE US?

• BASICS NEVER CHANGE:
  • NEED TECHNIQUE THAT IS EFFECTIVE, SAFE, QUICK, EASILY LEARNED, AND COST EFFECTIVE
  • HALSTED’S PRINCIPLES FROM 1800s:
    • GENTLE TISSUE HANDLING
    • GOOD BLOOD SUPPLY, WITH GOOD HEMOSTASIS
    • MINIMAL (NO) TENSION
    • ACCURATE TISSUE APPPOSITION
    • STRICT ASEPTIC TECHNIQUES

• SURGEON GETS TO CHOOSE:
  • HAND SEWN VS STAPLED
  • INVERSION VS EVERSION
  • SINGLE VS DOUBLE LAYER
  • CONTINUOUS VS INTERRUPTED
  • SUTURE MATERIAL
    • ABSORBABLE VS PERMANENT
    • MONOFILAMENT VS BRAIDED

WHAT TO CHOOSE?

• STAPLES VS SUTURES: LEVEL IA EVIDENCE OF EQUIVALENCE; STAPLERS FASTER BUT MORE EXPENSIVE

• INVERSION VS EVERSION: LEVEL IB EVIDENCE THAT INVERTING IS BETTER

• SINGLE VS DOUBLE LAYER: SINGLE LAYER QUICKER AND CHEAPER WITH EQUIVALENT RESULTS

• CONTINUOUS VS INTERRUPTED: EQUIVALENT WITH ONLY IIB DATA; CONTINUOUS QUICKER

• SUTURE MATERIAL
  • ABSORBABLE VS PERMANENT; SLOWLY ABSORBABLE OR PERMANENT BETTER
  • MONOFILAMENT VS BRAIDED; MONOFILAMENT BETTER
WHERE ARE WE NOW?

<table>
<thead>
<tr>
<th>Type of anastomosis</th>
<th>Incidence of anastomotic leak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esophageal</td>
<td>9.6%–14%</td>
</tr>
<tr>
<td>Stomach</td>
<td>1.1%–3.3%</td>
</tr>
<tr>
<td>Small intestine</td>
<td>1%–3.8%</td>
</tr>
<tr>
<td>Ileocolic</td>
<td>2%–6.5%</td>
</tr>
<tr>
<td>Colocolonic</td>
<td>3%–5.4%</td>
</tr>
<tr>
<td>Colorectal</td>
<td>7%–13%</td>
</tr>
<tr>
<td>Ileorectal</td>
<td>5%–19%</td>
</tr>
</tbody>
</table>

WHAT WE CAN CHANGE, AND WHAT WE CAN’T

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Abdominal ascites</th>
<th>Obesity*</th>
<th>Radiation therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malnutrition</td>
<td>Advanced malignancy</td>
<td>History of cardiovascular disease</td>
<td>Renal failure</td>
</tr>
<tr>
<td>Smoking</td>
<td>(metastatic disease)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steroid use</td>
<td>Alcohol abuse*</td>
<td>Previous history of smoking</td>
<td>Site of anastomosis (esophageal and low rectal have the highest risk)</td>
</tr>
<tr>
<td>Bowel preparation</td>
<td>Anemia</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diabetes</td>
<td>Male sex</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Emergency surgery</td>
<td>Medical comorbidity (high ASA)</td>
<td></td>
</tr>
</tbody>
</table>

<4 weeks) but long-term delay still unnecessary surgery
when pressors are used after transhiatal surgery
management and guidelines per institution, use the stents with (stapled)
TO CONCLUDE

• THE HISTORY OF GI ANASTOMOSES IS ONE MORE FASCINATING, CIRCUITOUS TALE OF SCIENTIFIC PROGRESS WITH PLENTY OF BIG AND INTERESTING PERSONALITIES

• KNOWLEDGE AND RESPECT FOR OUR HISTORY AND “WHERE WE HAVE COME FROM” INFORMS FUTURE DECISIONS AND RESEARCH, HOPEFULLY TO AVOID REPEATING MISTAKES OF THE PAST

• LIKE ALL OF SCIENCE, WE HAVE NOT REACHED "PERFECT" SO THERE WILL CONTINUE TO BE A PUSH TO IMPROVE TECHNIQUES AND OUTCOMES

“A surgeon...is a man who while observing with unaltering loyalty those practices which experience and experiment have together imposed upon him, refuses to be merely a mimic bound by custom and routine. He must set endeavor in continual motion and seek always and earnestly for simpler methods and a better way. In the craft of surgery the master word is SIMPLICITY.”

Sir Berkley G.A. Moynihan
Royal College of Surgeons 1920
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