Physiological Consequences of a Short Bowel

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Physiological Consequences of a Short Bowel

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• Definition and types of short bowel
• Problems of a short bowel
• Physiology - normal or altered
Short Bowel - Definitions

**Length**
- Less than 200 cm small bowel remaining.

**Function**
- Fasting plasma citrulline.

**Consequences**
- Reduced absorption that without treatment results in undernutrition, dehydration and / or reduced growth.

**Needs**
- Reduced absorption so that macronutrient and / or water and electrolyte supplements are needed to maintain health and / or growth.
Citrulline

Types of Patient with a Short Bowel

Jejunostomy

Jejunum-colon
Major Problems of Jejunostomy

• High output stoma
  Water, sodium and magnesium depletion

• Malabsorption
  Undernutrition
  $B_{12}$ deficiency

• No improvement with time

• Gallstones
Major Problems of Jejunum-colon

- Malabsorption
  - Diarrhoea (steatorrhoea)
  - Undernutrition
  - $B_{12}$ deficiency
  - Renal Stones
- Gallstones
Reasons for Jejunostomy Output

- Loss of normal daily secretions
- Iso-osmolar contents
- Gastric acid hypersecretion
- Increased gut transit
Daily Volume of Gastrointestinal Secretions

- 2.0 L food and drink
- 0.5 L saliva
- 2.0 L gastric juice
- 1.5 L pancreatico-biliary secretions
Jejunostomy Output in Patient with 30 cm Jejunum

Nightingale JMD et al. Lancet 1990; 336: 765-8

![Graph showing weight and oral intake compared to jejunostomy output over time.](image-url)
Net Intestinal Output and Jejunal Length

Nightingale JMD et al. Lancet 1990; 336: 765-8
Jejunostomy Classification
Nightingale JMD et al. Lancet 1990; 336: 765-8

SECRETORS
- intestinal output > oral intake
- negative water and sodium balance
- less than 100 cm jejunum

ABSORBERS
- intestinal output < oral intake
- positive water and sodium balance
- 100 - 200 cm jejunum
Iso-osmolar Contents - Jejunum

“Leaky” intercellular junctions

Water / Na+

Na+ / glucose pump

Stomal output

Osmolality 300 mOsm/kg
Na+ 100 mmol/L
**Iso-osmolar Contents - Jejunum**

*Elemental Diet*

- Hyper-osmolar
- Low sodium

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**PLASMA**

- Osmolality: 290 mOsmol / kg
- Water
- Na\(^+\): 140 mmol / l

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**Water**

**Na\(^+\)**
Denervated Gastric Pouch and Gastric Acid Hypersecretion
### Gastric Acid Hypersecretion in Man with a Short Bowel and a Colon

<table>
<thead>
<tr>
<th>Year</th>
<th>n</th>
<th>Gastric aspirate L/24hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>2</td>
<td>2.2 - 4.6</td>
</tr>
<tr>
<td>1967</td>
<td>1</td>
<td>3.0 – 4.0</td>
</tr>
<tr>
<td>1969</td>
<td>8/19*</td>
<td>&gt; 1.5</td>
</tr>
<tr>
<td>1971</td>
<td>8#</td>
<td>Basal and pentagastrin induced acid secretion increased</td>
</tr>
</tbody>
</table>

*: > 300 cm small bowel resected
#: Crohn’s and > 60 cm ileum resected
Gastric Acid Secretion in Jejunostomy Patients

O’Keefe SJD. Gastroenterology 1994; 107: 379-388

9 jejunostomy patients more than 1 year after surgery vs

9 healthy controls

“Baseline measurements of pentagastrin-stimulated acid secretion were no different between patients and healthy controls”
Increased Gut Transit

Stoma bag
15 MINUTES

LIQUID

SOLID

End Jejunostomy at 60 cm
Gastric Emptying of Liquid
7 Jejunostomy Patients
Nightingale JMD et al. Gut 1993; 34: 1171-1176
15 MINUTES

LIQUID

SOLID

Jejunum-Colon at 75 cm
Distal Gut Hormones to Slow Transit in Patients with a Short Bowel

PYY
GLP-2
Peptide YY in Patients with a Short Bowel

![Graph showing peptide YY levels in different conditions: Jejunostomy, Jejunum-colon, and Normal subjects. The graph includes time in minutes (0-180) and peptide YY levels in pmol/l. Significant differences are indicated with * (p<0.05) and ** (p<0.005).]
Hypomagnesaemia in patients with less than 200 cm jejunum

Nightingale JMD et al. Gut 1992; 33: 1493-7

<table>
<thead>
<tr>
<th>Procedure</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jejunostomy</td>
<td>31 / 40</td>
<td>78</td>
</tr>
<tr>
<td>Jejunum-colon</td>
<td>15 / 31</td>
<td>48</td>
</tr>
</tbody>
</table>
Fatty acids
Resection of ileum / colon
Dehydration (hyperaldosteronism)

Low Mg\textsuperscript{2+}

Parathormone
Secretion / function

Renal Mg\textsuperscript{2+} reabsorption
1\(\alpha\) hydroxylase activity
1, 25 - hydroxycholecalciferol
Gut magnesium absorption
Colonic Fermentation
Nordgaard I et al. Lancet 1994; 343: 373-376

Starch / soluble non-starch polysaccharides

<table>
<thead>
<tr>
<th>Anaerobic bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short chain fatty acids</td>
</tr>
<tr>
<td>butyrate</td>
</tr>
<tr>
<td>proprionate</td>
</tr>
<tr>
<td>acetate</td>
</tr>
</tbody>
</table>
25% Jejunum – colon patients develop symptomatic renal stones

Nightingale JMD et al. Gut 1992; 33: 1493-7
Formation of Calcium Oxalate Renal Stones

Ca-oxalate

FFA’s

Bile acids

Ca-FFA

Oxalate
Intestinal Adaptation

The process that attempts to restore the total gut absorption of macronutrients, macrominerals and water to that of before a resection.
Adaptation

• Hyperphagia

• Structural adaptation

• Functional adaptation
Structural Jejunal Adaptation in Man

**Jejunostomy**
- None (n=9)
  
  O’keefe SJD. Gastroenterology 1994; 107: 379-388

**Jejunum-colon**
- Epithelial hyperplasia (n=4)
  
  Porus RL. Gastroenterology 1965; 48: 753-59
- Epithelial atrophy (n=7)
  
  De Francesco A et al. Transplant Proc 1994; 26: 1455-6
Functional Adaptation in Man

**Jejunostomy (or ileal resection)**
- None

  Nightingale JMD et al. Gut 1992; 33: 1493-7

**Jejunum-colon**
- Increased absorption of macronutrients (glucose), water, sodium and calcium *
- Ability to stop parenteral nutrition

  Althausen TL et al. Gastroenterology 1950; 16: 126-34 *
  Dowling RH & Booth CC. Lancet 1966; ii: 146-7 *
  Gouttebel MC et al. Dig Dis Sci 1989; 34: 709-15 *
  Nightingale JMD et al. Gut 1992; 33: 1493-7
  Cosnes J. Eur J Gastroenterol Hepatol 1994; 6: 197-202 *
Enzyme Changes with Adaptation

**Animals**

Na\(^+\) / glucose co-transporter  
Na\(^+\) / H\(^+\) co-transporter

**Man**

Colonic di and tripeptide transporter  
(Pep T1) (5 x activity)

Gallstones in 84 Patients with a Short Bowel

Nightingale JMD et al; Gut 1992; 33: 1493-97

- Jejunostomy: 43%
- Jejunum-colon: 44%
Pathogenesis of Gallstones in Patients with a Short Bowel

Ileal disease / resection
Surgery
Weight loss
TPN
Drugs

stasis → sludge → Calcium bilirubinate gallstones
Summary - Physiological Consequences of a Short Bowel

**Jejunostomy**

- Water / Na⁺ losses  
  - normal secretions
  - hyperosmolar / low Na⁺ diet
  - rapid liquid gastric emptying

- Hypomagnesaemia  
  - secondary hyperaldosteronism

- Malabsorption  
  - undernutrition (B₁₂)

- No structural or functional adaptation

- Pigment gallstones
Summary - Physiological Consequences of a Short Bowel

**Jejunum-colon**

- Malabsorption
  - diarrhoea (?gastric acid hypersecretion)
  - undernutrition ($B_{12}$)
  - calcium oxalate renal stones

- Colonic fermentation
- Functional adaptation
- Pigment gallstones
Advantages of Preserving the Colon

- Water, sodium and magnesium absorption.
- Carbohydrate fermentation.
- Slows gastric emptying.
- Aids small bowel adaptation.
References

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Nightingale JMD. Management of patients with a short bowel.
World J Gastroenterol 2001; 7: 741-751


Key Words

Short Bowel
Intestinal failure
Ileostomy diarrhoea
Gastric acid
Hypomagnesaemia
Gallstones
Renal Stones
Intestinal Adaptation