

The intraindividual variation in small intestinal strength in the pig

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Introduction

A segment of intact bowel is used as the control when carrying out experiments regarding the bursting strength of sutureless fibrin glued anastomoses of the small bowel of pigs (Hjørtrup *et al.* 1986). In such experiments, it is necessary to keep the risk of intraperitoneal adhesions, resulting from the laparotomy, as low as possible. Therefore we employed a short laparotomy and used a random segment of the small intestine just inside the laparotomy incision as the site of the anastomosis as well as for the control segment. The investigation demonstrated considerable interindividual variation in the strength of the control segment, ranging from 78 to 170 mm Hg (Hjørtrup *et al.* 1986). The object of the present investigation was to determine whether these differences were a result of interindividual variation *per se* or whether some of the difference arises from intraindividual variation in small intestinal strength in the jejunum and ileum.

Material and methods

The present investigation was carried out taking due regard to the guide-lines laid down by the National Research Council for the care and use of laboratory animals.

Seven young female pigs, of the German Land race, with a median weight of 30 kg (range 26-35), were employed in this investigation. The animals were only permitted water for the last preoperative 24 hours. They were anaesthetized using sodium pentobarbital 20-30 mg/kg body weight, i.v. The pigs were then subjected to laparotomy via a midline incision. The strength of the small intestine was determined at ten different places – just anal to the ligament of Treitz (site 1); just oral to the ileo-coecal valve (site 10) and at eight locations at even distances between these two sites (sites 2, 3, 4, 5, 6, 7, 8, 9). The oral half of the small intestine

(sites 1-5) is termed the jejunum and the anal half (sites 6-10) the ileum.

The strength of the bowel segments was determined by means of the *in vivo* bursting strength method. The segments of bowel were tested in an oral-anal sequence. A ten cm segment of bowel was measured on the mesenteric side with a ruler, and closed by two ligatures. Water was then pumped into the segment via a catheter at a constant rate of 900 ml/hour, while a pressure curve was recorded in a Siemens Mingograph. The peak pressure recorded prior to bursting was employed as the end-point.

The results were subjected to statistical analysis. The bursting strength was compared at the corresponding sites on the jejunum and ileum (site 1 versus 6, 2 versus 7, 3 versus 8, 4 versus 9 and 5 versus 10) by means of the Wilcoxon paired rank sum test. The variance analysis was a non-parametric equivalent to a two-way analysis of variance (Friedman's chi-squared test). A level of significance of 5% was used.

Results

The strength of the various segments are shown in Figure 1. The median strength in the jejunum was 168 mm Hg (range 135-195), and in the ileum 196 mm Hg (range 142-274). This difference is significant.

Analysis of variance demonstrated that the variation as a result of the localization within the small intestine (abscissa on Figure 1) was greater than that expected from the strength variation between pig and pig (ordinate on Figure 1). In other words, the intraindividual variation could not be explained by the interindividual variation alone.

It can be seen from the curve (Figure 1) that the strength of the small intestine increases with increasing distance from the ligament of Treitz. Due to the small number of observations, it is impossible to calculate with statisti-

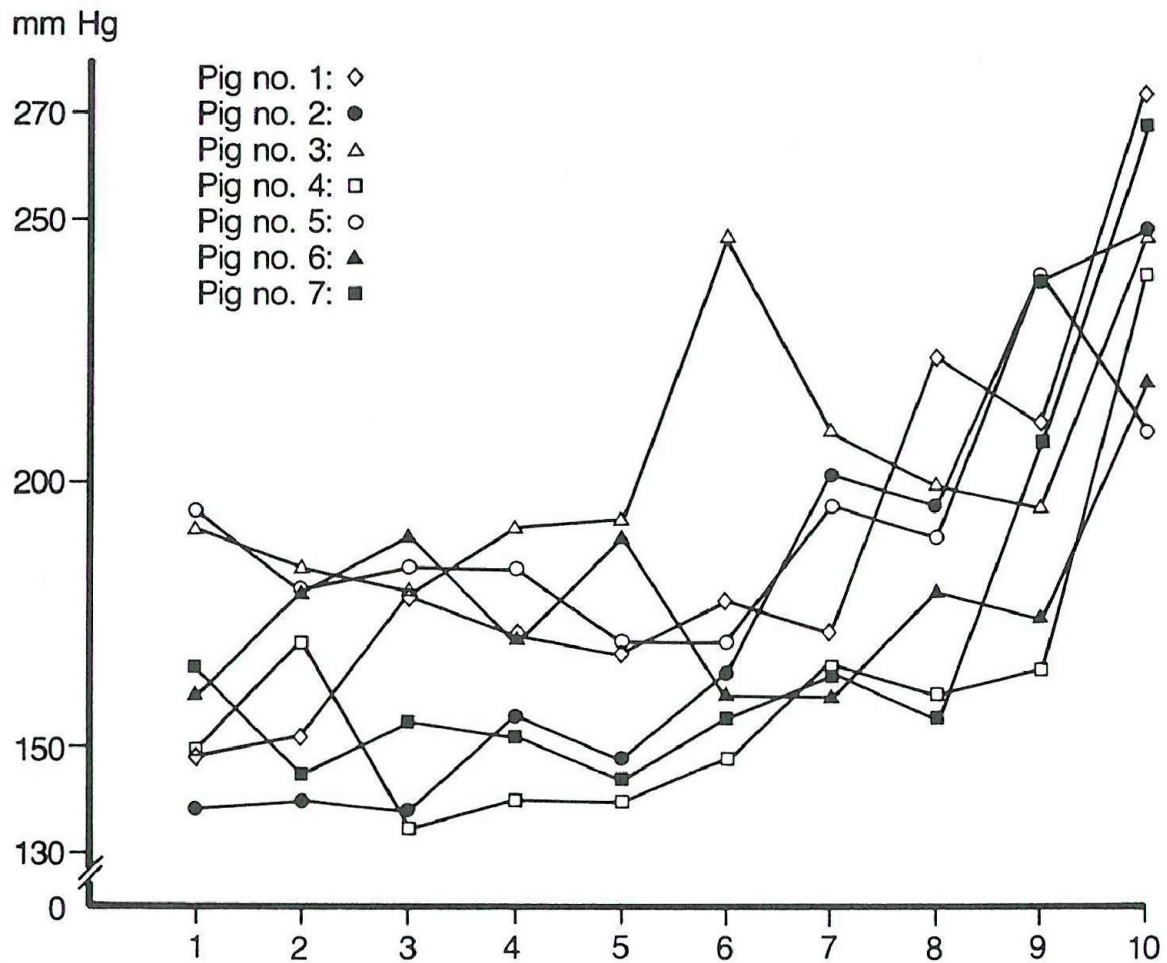


Figure 1. Bursting strength at ten different sites of the small intestine in seven pigs. Ordinate: Pig No 1-7. Abscissa: Site No 1, just anal to the ligament of Treitz, Site 10, just oral to the ileo-coecal valve. Sites 2-9, eight locations at even distances between sites 1 and 10.

cal certainty whether the increase is linear or exponential.

Discussion

The strength of the small intestine, as expressed by the bursting strength pressure, increased throughout the length of the small intestine in the present study. It was greatest in the ileum, particularly just orally to the ileo-coecal valve. There is a possible source of error in the physiological properties (Nielsen & Anders 1966), as expressed by the law of LaPlace ($T = P \times R$; $T = \text{Tension}$, $P = \text{Pressure}$, $R = \text{Radius}$). If this law is to explain the present differences in bursting pressure in the intestine of the pig, then the diameter close to the coecum must be roughly one half of that of the small intestine at

the ligament of Treitz. In general, the small intestine in man becomes narrower along its whole length (Ham 1974), but not to the extent mentioned above.

The breaking strength of the intact jejunum of rats was significantly greater than that of the ileum, and the difference correlated to the amount of collagen in the jejunum and ileum (Jönsson 1985).

Whether the significant differences in the intestinal strength in pigs and rats can be explained by anatomical and/or physiological differences is of little practical importance. The present investigation has demonstrated that when conducting studies on the strength of segments of the small intestine between groups of animals it is of the utmost importance to use similar sites

on the intestine in order to achieve comparability (Cronin *et al.* 1968). The same advantage can be obtained by employing an intraindividual comparison of neighbouring sites (Hjortrup *et al.* 1986; Kjærgaard *et al.* 1987).

It is concluded that similar sites of the intestine should be used when results on the strength of gut segments are to be compared from animal to animal (group comparison) and neighbouring sites when results are to be compared within animals (intraindividual comparison).

References

- Cronin, K., D. S. Jackson & J. E. Dunphy: Changing bursting strength and collagen content of the healing colon. *Surg. Gynaecol. Obstet.* 1968, 126, 747-753.
- Ham, A. W.: *Histology*. 7. Ed. J. B. Lippincott Company, Philadelphia, 1974, p. 662.
- Hjortrup, A., P. Nordkild, J. Kjærgaard, E. Sjøntoft & H. P. Olesen: Fibrin adhesive versus sutured anastomosis: A comparative intra-individual study in the small intestine of pigs. *Br. J. Surg.* 1986, 760-761.
- Jönsson, K.: *Healing of small intestinal anastomoses*. Thesis University of Lund, Malmö 1985.
- Kjærgaard, J., P. Nordkild, E. Sjøntoft, A. Hjortrup: A non-sutured fibrin adhesive versus sutured anastomosis. *Acta Chir. Scand.* 1987, in press.
- Nelsen, T. S., C. S. Anders: Dynamic aspects of small intestinal rupture with special consideration of anastomotic strength. *Arch. Surg.* 1966, 93, 309-314.

Summary

The object of the study was to determine the intraindividual and interindividual variation in the bursting strength of the small intestine of pigs.

Seven pigs were subjected to laparotomy and the *in vivo* bursting strength of the small intestine was determined at ten different sites. The strength of the small intestine increased with increasing distance from the ligament of Treitz. The median strength in

the jejunum was 160 mm Hg (range 135-195), in the ileum 196 mm Hg (range 148-274).

The variation between pig and pig was great, but the intraindividual variation could not be explained by the interindividual variation alone.

The results demonstrated that when conducting studies on the strength of the small intestine, it is of the utmost importance in order to achieve comparability, to use similar sites on the intestine when the study design is group comparisons, and neighbouring sites when the study design is intraindividual comparison.

Sammendrag

Formålet med studiet var at bestemme variationen i trykstyrken af tyndtarm hos svin.

Syv svin blev laparotomeret og *in vivo* trykstyrken af tyndtarmen målt på 10 forskellige steder. Styrken af tyndtarmen øgedes med øget afstand fra Treitz' ligament. Den mediane styrke i jejunum var 160 mm Hg (spændvidde 135-195) og i ileum 196 mm Hg (spændvidde 148-274). Denne forskel er signifikant. Den interindividuelle variation var stor, men den intraindividuelle variation kunne ikke forklares alene ved den interindividuelle variation.

I undersøgelser af tyndtarmsstyrke er det på denne baggrund væsentligt, at der ved gruppesammenligning anvendes identiske steder på tarmen og ved intraindividuel sammenligning tætliggende steder på tyndtarmen.

Yhteenveto/T. Nevalainen

Tässä tutkimuksessa pyrittiin selvittämään elimen saman osan käytön vaikutusta mittaamalla ohutsuolen puhkeamiskestävyys kymmenestä eri paikasta Treitzin ligamentin ja ileocekaalisen läpän välillä seitsemällä sialla. Puhkeamiskestävyys kohosi merkitsevästi ($p = 0,003$) ohutsuolta eteenpäin mentäessä. Tämä havainto osoittaa elimen tarkalleen saman kohdan käytön merkityksen.

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