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Motility and intraluminal pressure of the ileocolonic junctional zone and adjacent bowel in a canine model

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Summary. The exact role of the ileocecal valve (ICV) at the junction of small and large bowel is not well understood. Bowel segments used for the construction of urinary reservoirs incorporate the ICV. In the Indiana pouch its natural continence is used as one principle for achieving continence of the efferent limb. Motor activity and pressure in the ICV, the ileum and colon were registered in eight dogs. Myogenic activity of the bowel consisted of slow waves, irregular spontaneous contractions and superimposed spikes. Pressures of 7.2 ± 0.3 cmH_2O were recorded in the ileum and of 5.6 ± 0.4 cmH_2O in the colon. The pressure in the ICV was 12.7 ± 0.4 cmH_2O rising to 26.4 ± 2.2 cmH_2O during spontaneous depolarization. Balloon dilatation of the ileum resulted in relaxation of the ICV in 76% of experiments, whereas colonic distension was followed by a pressure increase in the ICV region in 80% of experiments. In 16% of cases a relaxation of the ICV area and a weaker response after repeated dilatation was noted. These findings make the ICV an unreliable continence mechanism as its long-term continence can not be predicted despite intraoperative evaluation. Additional measures to ensure consistent continence at the ICV (e.g. electric stimulation) need to be studied.

Key words: Ileocecal valve – Urinary diversion – Continence – Bowel pressure – Bowel motility

Intestinal motility is necessary for mixing of food with digestive enzymes, to support resorption through the bowel wall and to propel remnants to the rectum [12]. Urinary diversions in the form of continent reservoirs or orthotopic neobladders can be made of virtually all bowel segments and the stomach. Despite the use of detubularized bowel parts, pressure development in these various bowel segments may account for incontinence in urinary reservoirs, as small and large bowel motility and pressure development is either myogenic or neurohumorally controlled [4].

This study in dogs was performed to investigate the electric activity and pressure response of various bowel segments and to determine the pressures at the ileocecal valve (ICV) and define the sphincteric area.

The pressure response of the ICV to ileal and colonic distension was measured and the use of the ICV as a natural spincter mechanism for use in continent urinary diversion evaluated.

Materials and methods

In eight adult mongrel dogs weighing between 10 and 17.5 kg, anesthesia was induced with pentobarbital (30 mg/kg intravenously) following premedication with acepromazin maleate (0.15 mg/kg intramuscularly). The dogs were ventilated with air through an endotracheal tube. The ileum and colon were exposed through a midline laparotomy. All experiments were performed after the animal had fasted for at least 12 h.

Normal bowel activity was evaluated by observing contractions in the small and large bowel. Thereafter the colon was opened about 20 cm aboral of the ICV, the ileum about 15 cm from the ICV. The bowel was cleaned by rinsing with saline until clear irrigation fluid was obtained.

A 4F four-channel pressure membrane catheter (Heyer-Schulte, Goleta, Calif.) was positioned from the ileum through the ICV into the colon. One pressure sensor was placed in the colon, one balloon close to the ICV on the colonic side and the third balloon on the ileal side of the ICV. In a second experiment, the pressure balloons were placed from the colon through the valve to record pressure and activity in the ileum as well as in the ileocecal junctional zone.

Pressures were measured with Gould Statham P50 pressure transducers and recorded on a four-channel polygraph (Grass Model 7), which was calibrated prior to and after every study.

Following the recording of the resting pressures and bowel motility, a stimulus was produced by inflating a balloon dilatation catheter with a diameter of 15 mm and a balloon length of 4 cm (Microvasive) in either the terminal ileum or the ascending colon. Pressures and bowel motility were recorded. The duration of distension was between and 5 and 15 s (av. 8.3 s). A minimum of 5 min was allowed to elapse between the distending stimuli, which were carried out up to 10 times in a short interval. A decline below the resting pressure of the ICV after distension of the bowel was considered as relaxation of the sphincteric zone.

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Histologic sections from the ICV and the base of the cecum were stained with Masson's trichrome and van Gieson evaluated with regard to smooth muscle arrangement.

Results

Resting activity of the bowel

Ileum. The myogenic control of the ileum consisted of slow waves propagating from the duodenum/jejunum aborally. The rhythm of slow waves was around 10 contractions per minute along the ileum. A migrating complex of motor activity was noted with a cycle of 90–120 min irregularly along the ileum. Usually this irregular motor activity was interrupted by bursts of activity every 120 min resulting in high intraluminal pressure and propulsion of bowel contents.

Ileocecal valve. The ileocolonic junction zone itself showed spontaneous contractions. Three different patterns of motor activity at the ICV were noted:
(1) rhythmic waves propagated from the ileum through the ICV; (2) spontaneous contractions; and (3) bursts of activity (Table 1). The bowel adjacent to the ICV showed less spontaneous activity than areas further away.

Colon. Motility of the colon was similar to that of the ileum. Slow waves at a frequency of 6.4/min and superimposed spikes were noted. Duration of the spike bursts was different (5–20 s), resulting in aboral bowel movement (Fig. 1).

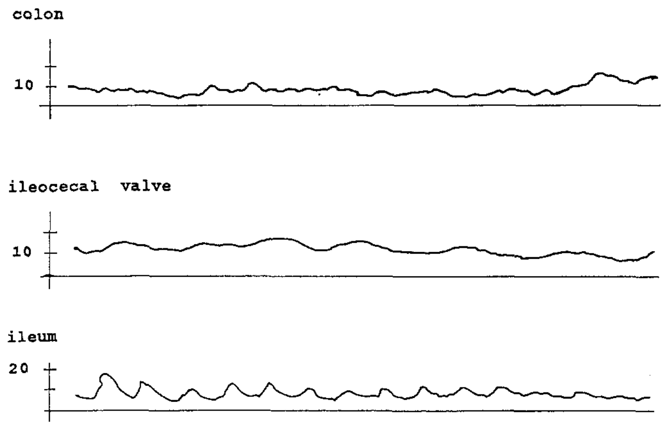

Fig. 1. Spontaneous activity of ileum, ileocecal valve and colon

Resting pressures

Pressure in the ileum was 7.2±0.3 cmH_2O and in the colon was 5.6±0.4 cmH_2O. The pressure in or close to the ICV was recorded as 12.7±0.4 cmH_2O on the ileal side and 10.6±0.6 cmH_2O on the colonic side. During spontaneous depolarization of the ileum, the pressure waves increased to 21.6±3.2 cmH_2O, whereas in the colon they reached only 15.4±1.9 cmH_2O. the ileocecal junction itself also showed pressure increases during spontaneous depolarization, to 26.4±2.2 cmH_2O on the ileal side and 18.6±2.1 cmH_2O on the colonic side. Interestingly, in about 70% of all bowel contractions the pressure on the ileal side of the ileocolonic area increased slightly before the pressure on the colonic side. In all cases the pressure in the ICV rose before the contraction wave from the colon could reach the ICV (Table 2). A spontaneous contraction wave of the ileum, however, did not result in a premature contraction of the ICV; instead the pressure wave traversed the ICV.

Pressure and motility changes after distension

Ileal distension resulted in relaxation of the ICV below the resting pressure in 76% of all experiments. In 50% of cases the relaxation was followed by a slight pressure increase for about 1 min thereafter, whereas relaxation alone with an increase in pressure to the resting tone was noted in the other half of the experiments. Contraction of the ICV with ileal distension was noted in 25% of the experiments (Fig. 2).

Colonic distension was followed by a pressure increase in the ICV region in 80% of cases, and by a slight relaxation in only 16% of all experiments. Relaxation after ileal distension was not only more frequent, but also greater. Colonic distension, on the other hand, resulted in a higher pressure increase in the ICV than did ileal distension (Fig. 3). A series of consecutive distensions resulted in a weaker pressure response in the ICV and was less reproducible than the response to one distension alone.

Distension of the ileum resulted in increased activity of the bowel in 80% of experiments, whereas colonic distension only stimulated activity in the colon in about 30% of all experiments.

Discussion

Physiologic considerations regarding the use of bowel segments for urinary diversions include intestinal motili-

Table 1. Motor activity at the ileocecal valve

	Duration (min)	Interval (min)	Propagation (cm/min)
Rhythmic waves (propagated from the ileum)	10 ±0.7	95 ±15	1.4±0.4
Spontaneous contractions	3.0±1.2	9.6± 0.3	1.6±0.3
Bursts	0.4±0.2	110 ±18	16.3±0.2

Table 2. Resting pressure and pressure during spontaneous depolarization in the distal ileum, colon and ileocecal valve (ICV)

	Resting pressure (cmH_2O)	Pressure during spontaneous depolarization (cmH_2O)
Ileum	7.2±0.3	21.6±3.2
Colon	5.6±0.4	15.4±1.9
ICV		
Ileum	12.7±0.4	26.4±2.2
Colon	10.6±0.6	18.6±2.1

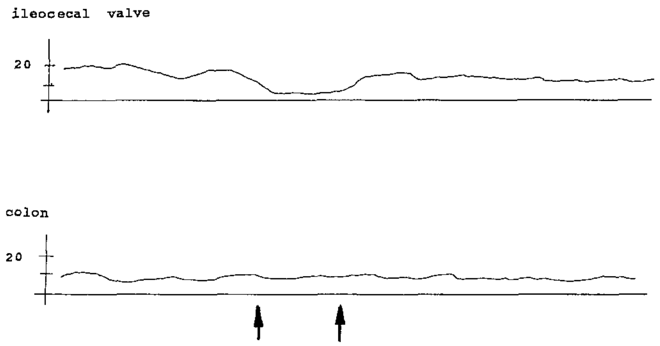

Fig. 2. Pressure in the colon and ileocecal valve (ICV) during ileal balloon distension. A decrease in ICV pressure is noted during distension (between *arrows*)

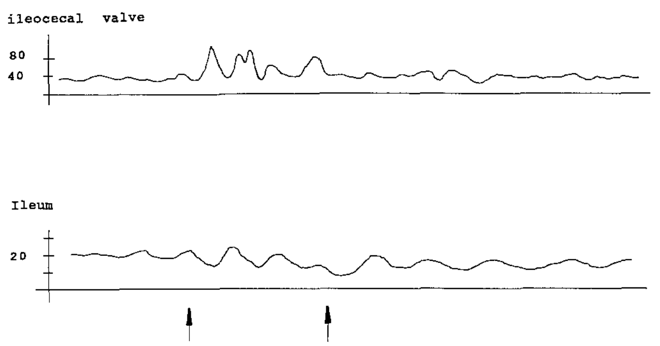

Fig. 3. Pressure in the ileum and (ICV) during colonic balloon distension. An increase in ICV pressure and activity is noted during distension (between *arrows*)

ty, intraluminal pressures, absorptive capacity of bowel mucosa, morphologic changes of mucosa in contact with urine and potential malignant growth in the diverted intestinal segments. Despite detubularization of bowel segments, intraluminal pressures rise in urinary reservoirs after reorganization of the bowel segments as electric activity and motility are myogenic or neurohumorally induced [1, 8].

Three types of motor activity are found, which also exist after detubularization and result in irregular contractions of the urinary reservoir: slow waves (rhythmic waves, usually with low pressure development; spontaneous contractions; and spikes which create higher pressure. These spikes are thought to be responsible for nocturnal incontinence in a full urinary neobladder as pressure may exceed sphincteric resting pressure [5, 7]. However, loss of afferent fibers from the bladder, to control sphincteric tone according to bladder fullness, may play a more important role. The relaxed spincteric mechanism at night has no efferent input from the neobladder, as no afferent fibers are preserved [6].

There is no well-defined, anatomically circumscribed spincteric area at the human or canine ileocecal junctional zone. Reflux from the colon into the terminal ileum can be prevented by the ICV. When moving a pressure transducer through this region, a high-pressure zone is regularly found in the ileocecal area [3, 11, 13]. Histologically a thickening of the smooth muscle in the ileocecal junctional area is encountered, suggesting a sphincteric mechanism.

In man the valve is only competent in about 60–70% of cases, permitting only passage of feces from the ileum into the colon. It has to be reinforced to provide reliable continence in a continent pouch. Interestingly, contraction of the ICV with a rise in intraluminal pressure preceded the pressure increase induced by colonic distension. Colonic distension simulating the filling of the urinary reservoir resulted in contraction of the ICV in 80% of cases; however, the ICV relaxed in 10% of experiments. Colonic distension resulted in a higher increase in pressure in the ICV compared with ileal distension. A series of distensions, however, weakened the response of the ICV relative to one distension alone. Resting pressures at the ileocolonic junctional zone were well above the resting pressures of the colon and the ileum. A peristaltic wave traversed the ICV with a consecutive pressure rise.

Similar findings have been demonstrated at the human ileocecal zone, with a clar drop in ICV pressure to slightly above the colonic pressure. Pressure increases from the colonic side mostly resulted in a rise in pressure in the ICV, thus preventing reflux through the valve [2, 10]. Spontaneous phasic motor activity arises in the ileum, colon and the ICV itself [1, 9]. Despite a resting tone above the cecal pressure the natural continence mechanism can be overcome by colonic distension in about 10% of cases as relaxation of the ICV ensues, and also by repeated colonic distensions. The natural continence of the ICV alone is thus not a consistent and reliable continence factor for a continent urinary reservoir, as the valve may leak even if its competence has been evaluated intraoperatively. Tapering and plicating of the ileal efferent segment are needed to increase the continence of the valve sufficiently for it to be used as an outlet for a urinary reservoir (Indiana pouch). Additional effects on the ileoceecal valve (such as electric stimulation) may also be applied to enhance the natural continence of the valve.

References

1. Christensen J, Schedl HP, Clifton JA (1966) The small intestinal basic electrical rhythm (slow wave) frequency gradient in normal men and in patients with a variety of diseases. Gastroenterology 50:309–312
2. Cohen SL, Harris LD, Levitan R (1968) Manometric characteristics of the human ileocaecal junction zone. Gastroenterology 54:72–75
3. Elliot TR (1904) On the innervation of the ileocolic sphincter. J Physiol (Lond) 31:157–168
4. Fleckenstein P (1978) Migrating electrical spike activity in fasting human small intestine. Am J Dig Dis 23:769–774
5. Hirst GDS (1979) Mechanisms of peristalsis. Br Med Bull 35:263–268
6. Jakobsen H, Steven K, Stigsby B, Larskov P, Hald T (1987) Pathogenesis of nocturnal urinary incontinence after ileocaecal bladder replacement: continuous measurement of urethral closure pressure during sleep. Br J Urol 59:148–152
7. Kelley ML, Gordon EA, De Weese JA (1965) Pressure studies of the ileocolonic junctional zone of dogs. Am J Physiol 209:333–339
8. Kock NG, Hulten L, Leandoer L (1968) A study of different parts of the human colon. Scand J Gastroenterol 3:162–169
9. Pahlin PE (1975) Exrinsic nervous control of the ileocaecal sphincter in the cat. Acta Physiol Scan [Suppl]426:5–32

10. Quigley EMM, Philipps SF, Dent J (1984) Distinctive patterns of interdigestive motility at the canine ileocolonic junction. Gastroenterology 87:836–844
11. Tönnis W (1924) Die Funktion der Valvula ileocaecalis. Arch C Physiol 204:477–482
12. Vantrappen G, Jannsens J, Covemans G, Jian R (1986) Gastrointestinal motility disorders. Dig Dis Sci 31:5–25
13. White HL, Rainey WR, Monaghan B, Harris A (1934) Observations on the nervous control of the ilecolonic sphincter and on intestinal movements in an unanaesthetized human subject. Am J Physiol 108:449–457

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