ORIGINAL ARTICLE

Double-balloon enteroscopy

The first fifty investigations in the Czech Republic

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Abstract. *Double-balloon enteroscopy (DBE) is a new technique for endoscopic investigation of the small intestine, recently introduced into clinical practice. This paper provides an analysis of our first fifty investigations in 40 patients (21 men, 19 women, mean age 52 years). Eight patients underwent a total of 18 DBEs. Panenteroscopy was successfully carried out in 4 of 42 oral DBEs (9.5 %) in one session. Diagnostic yield was 70 % in our series. The average procedure duration, including insertion of the enteroscope, observation and/or therapeutic procedure, was 130 min. (range 20 – 240 min., median 130 min.). One patient developed mild acute oedematous pancreatitis after the oral DBE. We had no other major complication. DBE is a feasible and safe new endoscopic technique with a high diagnostic yield and therapeutic impact in small intestinal pathology.*

Key words: *double-balloon endoscopy, enteroscopy, small intestine, endoscopic treatment*

Kopáčová M, Rejchrt S, Tachecí I, Bureš J. Dvojbalonová enteroskopie. Prvních padesát vyšetření v České republice. Folia Gastroenterol Hepatol 2006; 4 (4): 135 – 148.

Souhrn. *Dvojbalonová enteroskopie (DBE) je nová technika endoskopického vyšetření tenkého střeva, která byla nedávno zavedena do klinické praxe. Tato práce přináší analýzu prvních 50 vyšetření u 40 pacientů (21 mužů, 19 žen, průměrného věku 52 let). Osm nemocných bylo vyšetřeno opakovaně (celkem 18 DBE). Panenteroskopie z orálního přístupu byla úspěšná ve 4/42 případech (9,5 %). Diagnostická výtěžnost DBE byla 70 %. Průměrná doba vyšetření, včetně zavedení enteroskopu, vlastního vyšetření a případného léčebného zákroku, byla 130 min. (v rozmezí 20 – 240 min., medián 130 min.). U jednoho pacienta došlo po DBE k mírné akutní edematózní pankreatitidě, jinou vážnější komplikaci DBE jsme nezaznamenali. DBE je příhodná a bezpečná metoda s vysokým diagnostickým přínosem a novými terapeutickými možnostmi pro řešení patologie tenkého střeva.*

Klíčová slova: *dvojbalonová endoskopie, enteroskopie, tenké střevo, endoskopická léčba*

Double-balloon enteroscopy (DBE), also known as push-and-pull enteroscopy, is a novel technique developed by Yamamoto et al. at the Jichi Medical School in Japan and first published in 2001 (20-22). The system consists of a 200-cm enteroscope and 145-cm over-tube which have soft latex balloons at their tips. Both balloons can be alternately inflated and deflated by an air balloon-pump controller. DBE is based on a new insertion technique in which these two balloons are operated in combination, and the endoscope is inserted while simultaneously shortening the intestine. It can be inserted through either the mouth or the anus, allowing for observation of the entire gastrointestinal tract (24).

Attempts to observe the entire gastrointestinal tract began even with early fibroscopes, and two successful methods were developed in addition to intra-operative enteroscopy: the ropeway method and the sonde endoscope. The very first successful total enteroscopy was performed in March 1971 by Dr. Hideo Hiratsuka, using the ropeway method (9,24). However, both of these methods are obsolete nowadays. Push-enteroscopy, using a long endoscope, has been regarded as a gold standard then, but most of the small intestine remains beyond its reach. Recent innovations and introduction of two new methods (wireless capsule endoscopy and DBE) made observation of the entire small intestine possible (24). Both of these techniques are now available in clinical practice and are complementary: capsule

endoscopy for screening and double-balloon enteroscopy for further diagnostics and/or therapy.

A few technical points have recently been discussed: the depth of insertion of the endoscope remains difficult to evaluate, so the precise location of lesions is almost impossible. The duration of the procedure and the discomfort for the patient caused by oral passage of the over-tube require deep analgosedation. The cost of the procedure is high (the over-tube and balloons are designed for single use). The procedure requires an experienced endoscopist and fluoroscopy at one's disposal, especially at the beginning, during the learning curve (6). Severe complications are described in about 1 % of the patients.

Patients and Methods

DBE has previously been reported to allow endoscopic examination of the entire small intestine, with interventional capabilities (24). The typical endoscopic appearance of the jejunum and ileum is seen on

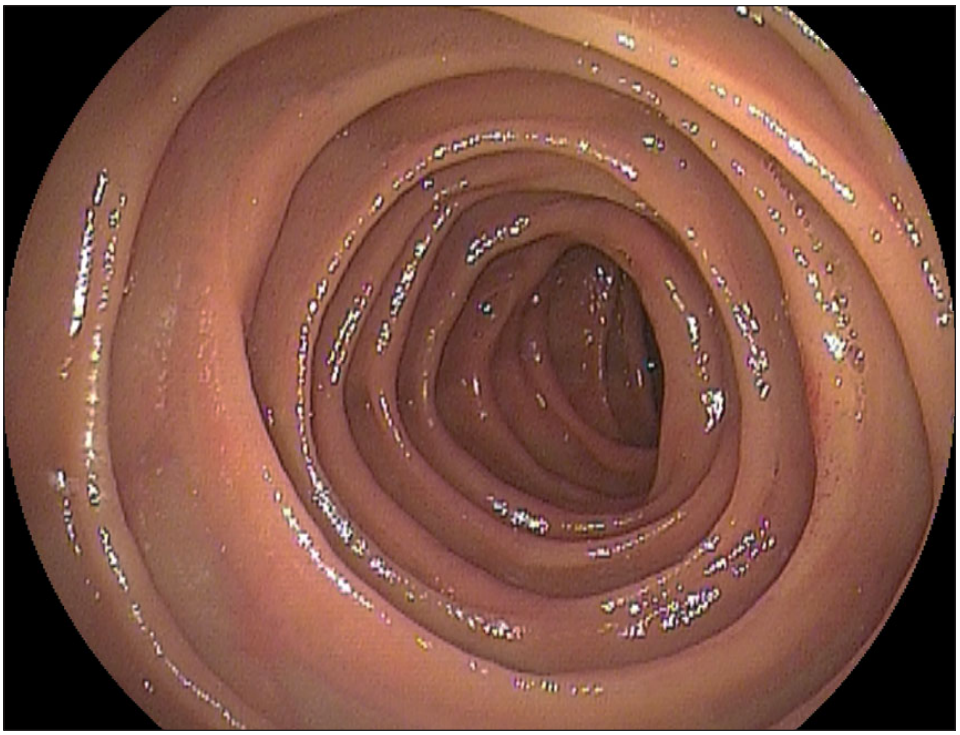

Fig. 1
Normal jejunum with multiple characteristic circular transverse folds (Kerkring's folds).

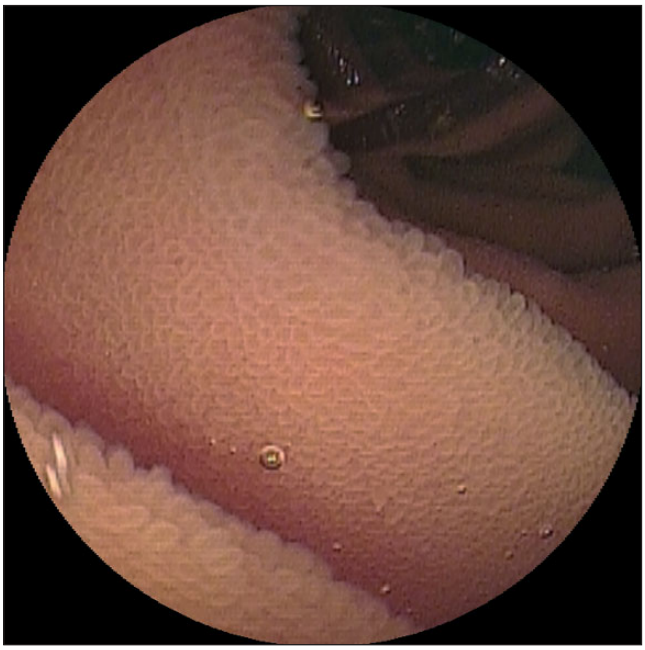

Fig. 2
Normal jejunum. An immersion picture (water is infused into the small-bowel lumen). Dense villi in the proximal jejunum.

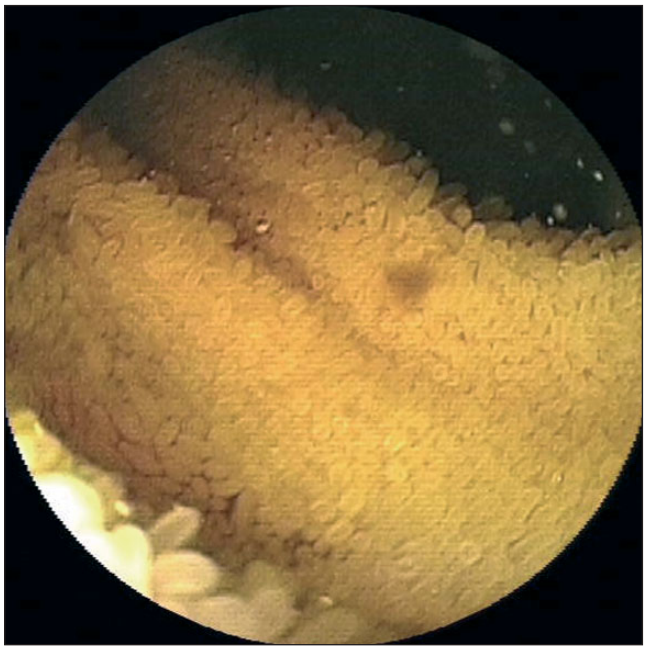

Fig. 3
Normal ileum. An immersion picture of conic villi.

Figs 1 – 4. Currently, two different diameter enteroscopes are available: EN-450P5 (Fujinon, Tokyo, Japan) with an outer diameter of 8.5 mm (an over-tube with an external diameter of 12.2 mm) and EN-450T5 with an outer diameter of 9.3 mm at a flexible tip and 9.4 mm at the remaining part of the endoscope (an over-tube with an external diameter of 13.2 mm). With a larger accessory (working) channel (2.8 mm in contrast to 2.2 mm in EN-450P5), EN-450T5 allows for the performance of a wide spec-

Table
Characteristics of patients

No.	Age/sex	Indication	Findings	Time	AS
1	35/F	GIT bleeding	Crohn's disease, ulcers	105*	Y
2	27/F	Suspicion of Crohn's disease	Normal	120	N
3	48/M	GIT bleeding	Normal	105	N
4	52/M	Capsule retention, Crohn's stenoses	Crohn's disease, wireless capsule extraction	75	Y
5	86/M	GIT bleeding	Jejunal AVM, coagulation	200	N
6	80/F	GIT bleeding	Jejunal AVM coagulation	195	Y
7	77/M	Suspicion of carcinoid	Brunneroma	200	Y
8	55/F	GIT bleeding	Jejunal varices, portal hypertension	75	Y
9	52/M	Crohn's disease, ileal stenoses	Crohn's disease, ileal stenoses, dilatation	150	Y
10	70/M	GIT bleeding	Jejunal varices	170	Y
11	41/F	Juvenile polyposis	Jejunal polyps, juvenile	95	Y
12	39/M	GIT bleeding	Normal	**185***	Y
13	76/F	Coeliac disease, subileus	Ileal lymphoma	90	Y
14	43/F	Crohn's disease, subileus	Crohn's disease, ileal stenoses, ulcers	**110***	Y
15	34/M	Coeliac disease	Coeliac disease	140	N
16	36/M	Crohn's disease, ileal stenoses	Crohn's disease, ileal stenoses, dilatation	120	Y
17	52/M	Crohn's disease, ileal stenoses	Crohn's disease, ileal stenoses, dilatation	195	Y
18	60/M	GIT bleeding	NSAIDs ulcers	150	N
19	49/F	Suspicion of jejunal stenosis	Normal	210	Y
20	75/M	GIT bleeding	Jejunal AVM, coagulation	240	N
21	68/F	GIT bleeding	Post-irradiative ulcer	210	Y
22	43/M	Subileus condition	Jejunal lymphoma	60	Y
23	38/M	Coeliac disease	Coeliac disease	140	N
24	36/M	Crohn's disease, ileal stenoses	Crohn's disease, ileal stenoses, dilatation	130	Y
25	30/F	Peutz-Jeghers syndrome	Multiple hamartomas, polypectomy	140	Y
26	35/M	GIT bleeding	Normal	105	Y
27	33/M	Familiar adenomatous polyposis	Adenomatous polyps, NSAIDs ulceration	115	Y
28	73/F	GIT bleeding	Jejunal diverticulas	160	N
29	60/F	GIT bleeding	Normal	175	Y
30	66/M	GIT bleeding	Jejunal AVM, coagulation	135	N
31	74/F	GIT bleeding	Jejunal AVM, coagulation	45	N
32	52/M	Crohn's disease, ileal stenoses	Crohn's disease, ileal stenoses, dilatation	120	Y
33	39/F	Crohn's disease, ileal stenoses	Crohn's disease, ulcers, stenosis	35	Y
34	33/M	Crohn's disease	Crohn's disease, ulcers, stenosis	20	N
35	66/M	GIT bleeding	Aphthous jejunitis, NSAIDs	75	Y
36	50/M	NSAIDs, subileus	Diaphragm-like stenoses, dilatation	180	N
37	33/M	Familiar adenomatous polyposis	Jejunal adenomatosis	**160***	Y
38	39/F	Suspicion of Crohn's disease	Normal	180	Y
39	36/M	GIT bleeding	Two jejunal lipomas	50	N
40	17/F	Peutz-Jeghers syndrome	Jejunal hamartomas, polypectomy	180	N
41	56/M	GIT bleeding	Jejunal lymphoma	140	Y
42	57/F	Hypoproteinaemia	Normal finding, mucosal oedema	90	N
43	63/F	GIT bleedingI	leal AVM, coagulation	100**	Y
44	77/M	Suspicion of carcinoid	Failure of terminal ileum intubation	90**	Y
45	41/F	Polyposis	Colonic polyps (juvenile), normal ileum	150**	Y
46	70/F	GIT bleeding	Failure of terminal ileum intubation	90**	Y
47	33/F	Polyposis	Normal (hyperplastic colonic polyps)	130**	Y
48	66/M	GIT bleeding	Normal ileum	100**	Y
49	59/M	GIT bleeding	Normal ileum (caecal AVM, coagulation)	160**	N
50	50/M	Jejunal stenoses (NSAIDs)	Normal ileum	80**	N

AS – prior abdominal surgery (Y – yes, N – no), Time – duration of procedure in minutes, M – male, F – female, GIT – gastrointestinal tract, NSAIDs – non-steroidal anti-inflammatory drugs, AVM – arterio-venous malformation

*Complete enteroscopy by oral route, **DBE by anal route

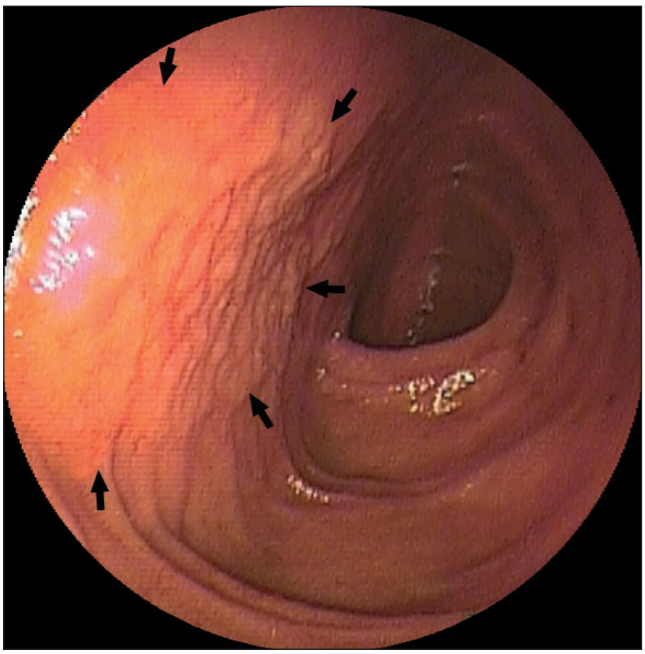

Fig. 4
Peyer's patches (agminated glands) in the ileum (arrows). Aggregations of solitary glands, forming circular or oval patches from 20 – 30 in number and varying in length is a normal finding, especially in children and young adults. Peyer's patches are largest and most numerous in the ileum. Normal ileum – mucosal folds are sparse and thicker in comparison with the jejunum.

trum of therapeutic endoscopic methods, including bipolar or argon plasma coagulation, polypectomy or balloon-dilatation (10,12,24).

Our centre has long-term experience with both push-enteroscopy (3) and intra-operative enteroscopy (11). We were the first in the Czech Republic to begin with DBE. This specialized method has only been available in our unit since March 2006. Most of our investigations were performed using the EN-450T5 enteroscope (Fujinon Corporation, Saitama City, Japan). We chose this device precisely because of its wider therapeutic possibilities. An EN-450P5 enteroscope (Fujinon Corp.) was used in only six procedures (four oral and two aboral investigations). Detailed information on our patients, including indications, endoscopical findings and possible therapy, is stated in Table 1.

Our first fifty DBEs (42 by oral and 8 by aboral route) were performed from March 2006 to December 2006 in 40 patients (21 men, 19 women, mean age 52 years, median 51, range 17 – 86), eight patients underwent a total of 18 DBEs (a 52-year-old man and 36-year-old man with Crohn's disease underwent altogether six oral DBEs with balloon dilatation of small-bowel stenoses, a 33-year-old man with adenomatous polyposis and jejunal ulceration had two oral DBEs, five patients had both oral and anal DBE subsequently). Panenteroscopy was successfully carried out in 4 of 42 oral DBEs (9.5 %) in one session (Figs 5-6). We used fluoroscopy during the procedure in one patient only (enteroscopy capsule retrieval) and in several ERCP procedures performed by DBE route (Figs 7 and 27).

The average procedure duration, including insertion of the enteroscope, observation and/or therapeutic procedure, was 130 min. (range 20 – 240 min., median 130 min.), in our four patients with complete enteroscopy (reaching the caecum by an oral approach) the average duration of the procedure was 140 min. (range 105 – 185 min.).

All patients were admitted to hospital at least one day before the procedure. The day before the investigation a standard preparation of the bowel (the same as for colonoscopy) follows (orally administrated sodium phosphate or macrogolum solution) before aboral approach. For oral DBE 12-hour fasting is sufficient. A venous access is obtained before the examination. All patients are monitored during the procedure. The same intravenous conscious analgo-sedation (combination of midazolam and pentazocine batch-wise) has been used in all subjects. Written informed consent was obtained from each patient prior the enteroscopic procedure.

Results

We performed 50 procedures from March 2006 till December 2006. Indications for DBE were gastrointestinal bleeding from an unknown origin (22 DBEs), Crohn's disease (11 DBEs), small intestinal polyps (7 DBEs), suspicion of carcinoid tumour (2 DBEs), coeliac disease (3 DBEs), NSAIDs-associated enteropathy (2 DBEs), suspicion of jejunal stenosis (1 DBE), partial small bowel obstruction (1 DBE) and severe hypoproteinaemia of unknown aetiology (1 DBE). The procedure was diagnostic in 35/50 patients (70 %), in 13 DBEs no small-bowel pathology was found (only arteriovenous malformation of the caecum in one patient, colonic polyps in one patient and oedema of the small bowel mucosa in the patient with severe hypoproteinaemia); and an intubation of the terminal ileum failed in two patients with aboral DBE.

DBE findings in our patients were arteriovenous malformations (Figs 17-18) in 6 DBEs, malformations were coagulated during the procedure, Crohn's disease (Figs 14-16) in 10 DBEs, polyps in 6 DBEs (2

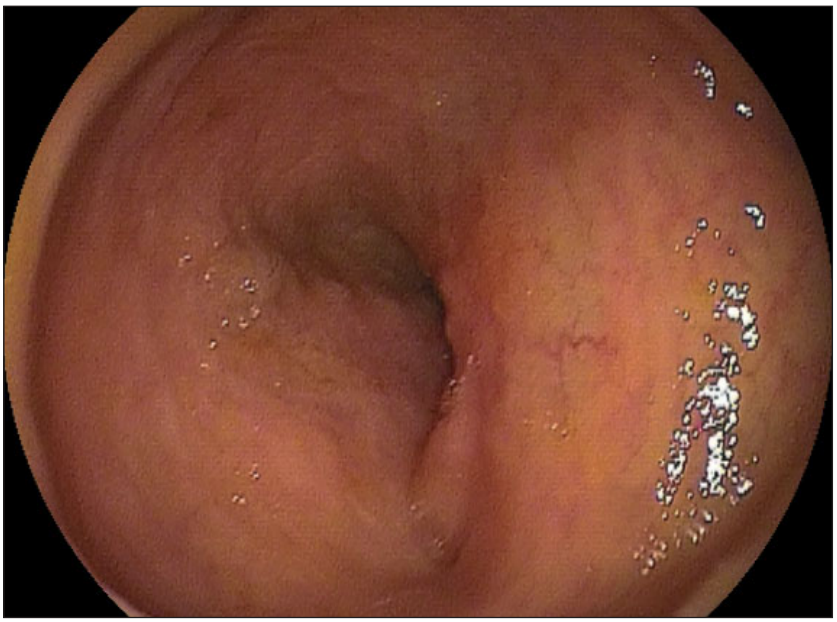

Fig. 5
Normal ileocaecal valve from the side of the terminal ileum. Panenteroscopy by an oral route.

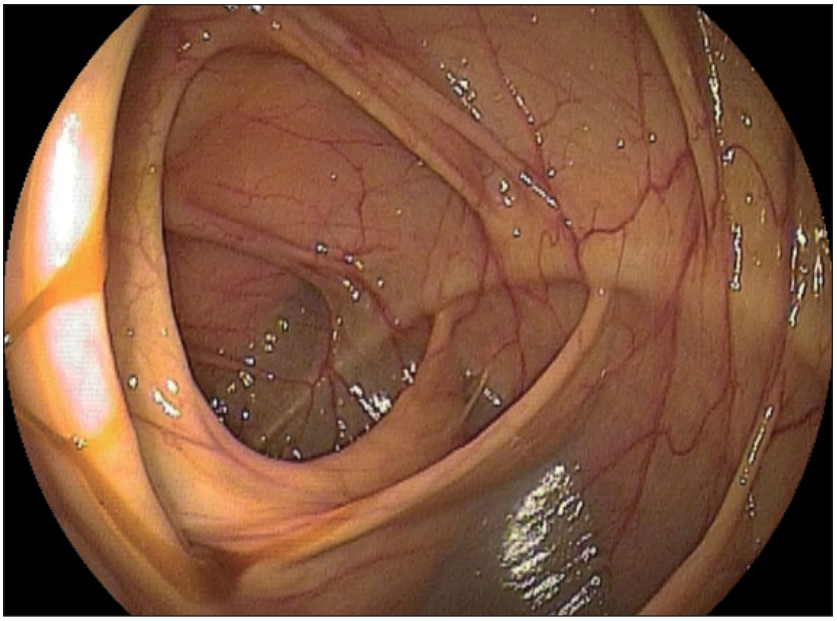

Fig. 6
A view of ascending colon and hepatic flexure from the ileocaecal valve during panenteroscopy by an oral route.

juvenile, 2 Peutz-Jeghers syndrome (Figs 20-22) and 2 familial adenomatous polyposis (Fig.), NSAIDs enteropathy in 4 patients, but one of them had concurrently familial adenomatous polyposis (patient No. 27). In those four subjects, we found ulcers in 2, aphthous lesions in one and diaphragmatic stenoses in one patient (Figs 23-24), small intestinal lymphoma (Figs 9-13) in 3 persons (one with coeliac disease – patient No. 13), coeliac disease without lymphoma in 2 subjects, lipoma in one person, post-radiation ulcer (Fig. 26) in one patient, jejunal varices in two subjects with portal hypertension, and brunneroma in one case. In two patients we found jejunal diverticulas as as additional finding (Fig. 25).

The investigation was therapeutic in 15/50 DBEs (30 %) – we performed coagulation of bleeding lesions in six patients, polypectomy in two, dilatations of fibrotic Crohn's stenoses in five, dilatation of NSAIDs-associated diaphragm-like stenoses in one and wireless capsule extraction in one subject. Only 3 patients (6 %) required subsequent surgery after diagnostic DBE (two with small-bowel lymphoma because of partial small bowel obstruction (subileus) and bleeding and one with post-radiation ulcer because of bleeding and stenosis). In those three cases sub-mucosal application of the Indian ink (Spot solution – tattooing) was performed close to the lesion for it to be easily located by a surgeon (Figs 8 and 10).

We have had only one serious procedure-related complication. One patient (No. 24) developed acute

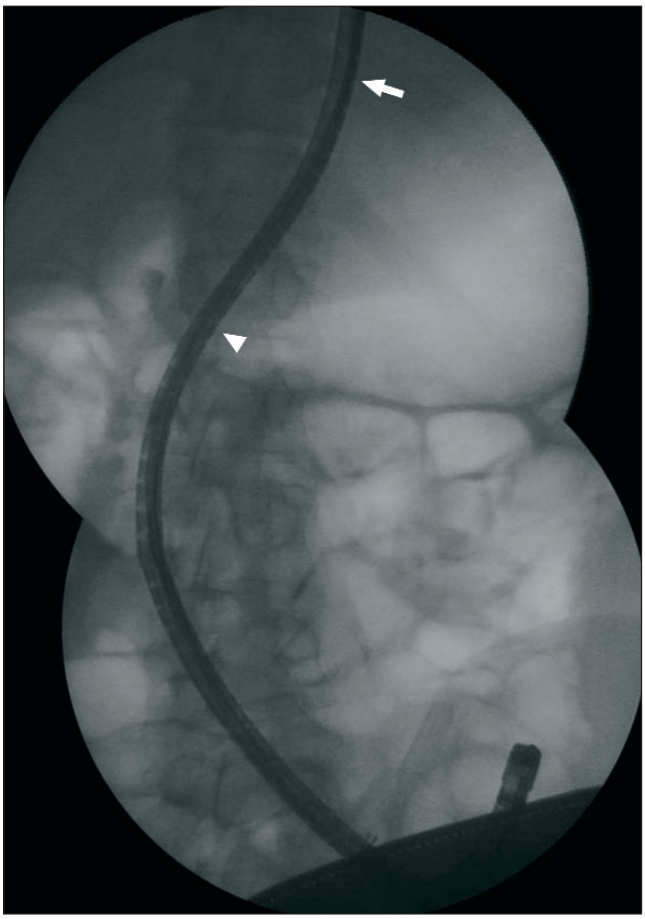

Fig. 7
A fluoroscopic picture of a double-balloon enteroscope. The jejunum is pleated on the scope. The area of the cardia is marked with arrow, the pylorus with an arrowhead. Remarcable mobilisation of duodenal-jejunal flexure is nicely demonstrated.

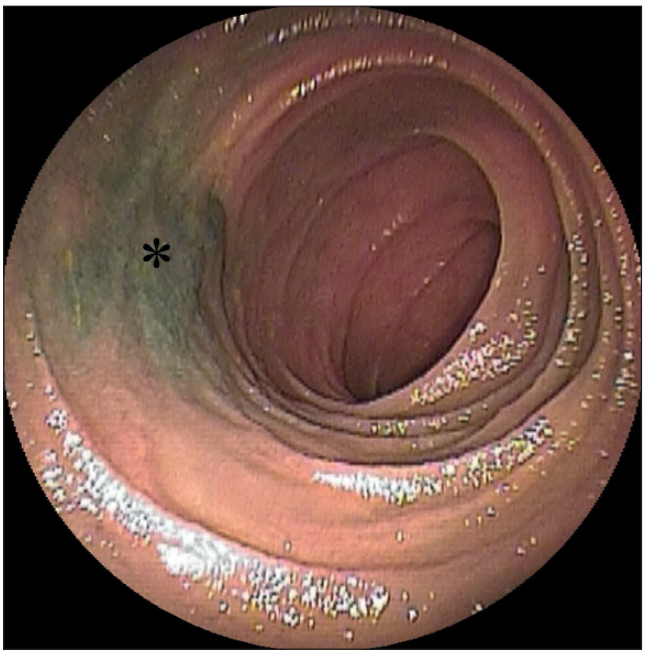

Fig. 8
Tattooing (asterisk) after a submucosal application of Indian ink (Spot® solution). This picture was taken 4 months after the injection.

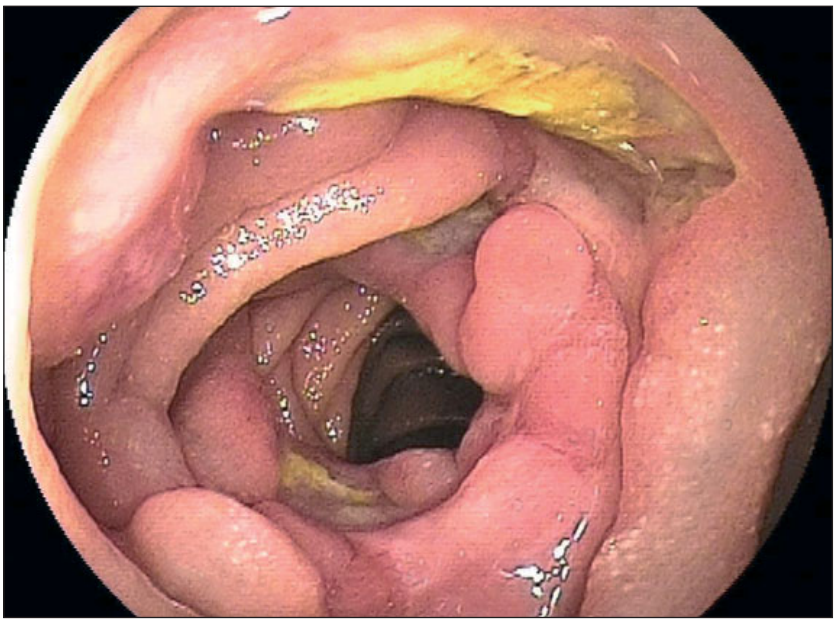

Fig. 9
Small bowel B-cell lymphoma. Swelling nodulated mucosa with ulcerations.

pancreatitis after the oral DBE (a 36-year-old man, duration of the enteroscopy was 130 min.). The pancreatitis was mild and oedematous according the CT-scan and course of the illness. We had no other major complication.

In one case (patient No. 40) we had to solve serious arterial bleeding after polypectomy, we achieved haemostasis using coagulation when the bleeding stalk after polypectomy (Forrest Ia) was caught by a polypectomy snare, kept for a few minutes and very

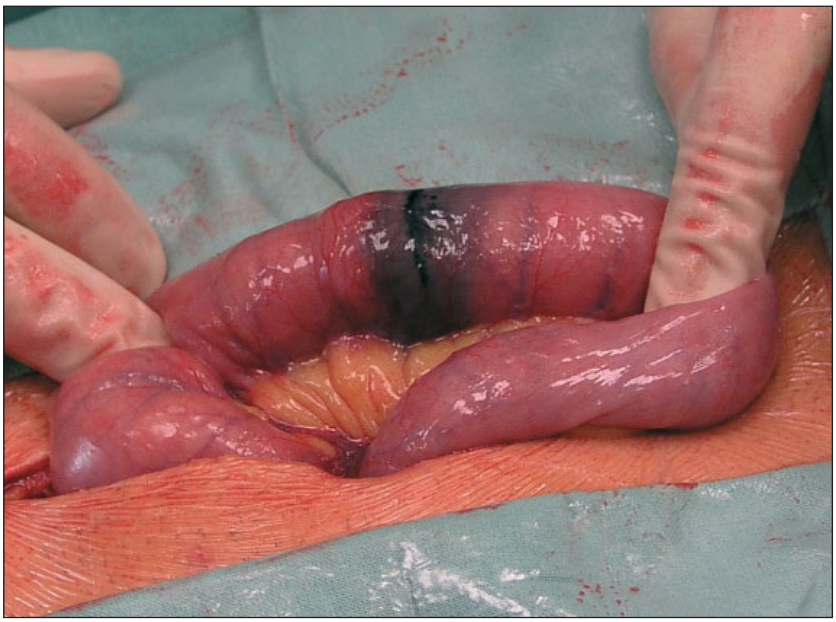

Fig. 10
Small bowel B-cell lymphoma (the same patient as seen on the Fig. 9) in the operating theatre. Tattooing (Spot®) is nicely seen on the serosal side of the small intestinal wall.

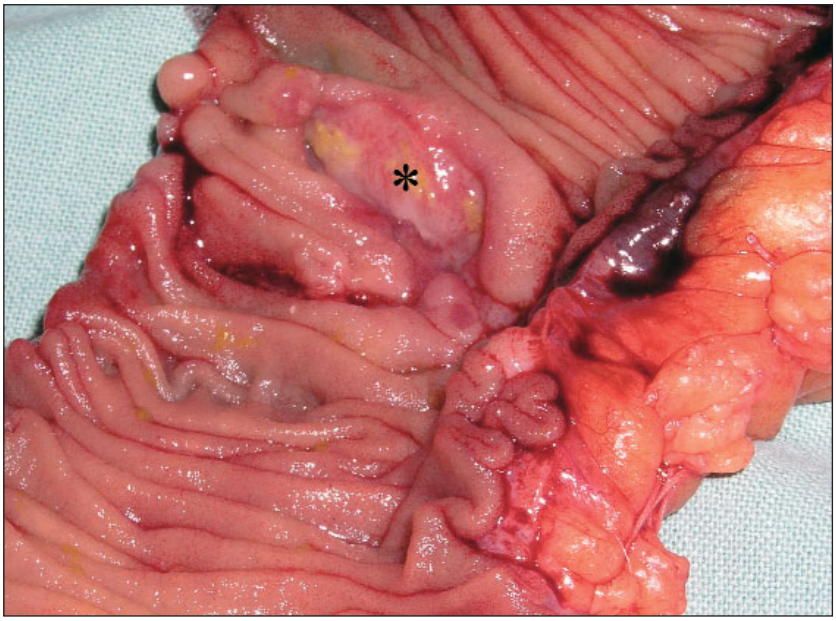

Fig. 11
Small bowel B-cell lymphoma (the same patient as seen on the Figs. 9 and 10). Resected part of the small bowel. The bowel is gashed lengthwise and the lymphoma is marked with an asterisk.

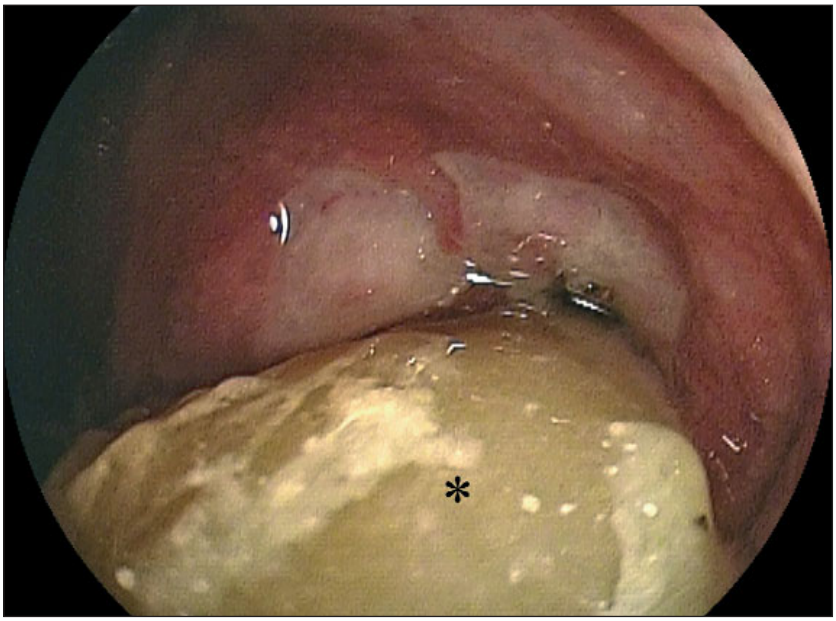

Fig. 12
Coeliac disease, the stenosis is caused by T-cell lymphoma. Impacted remnant of fruit parings is marked with an asterisk.

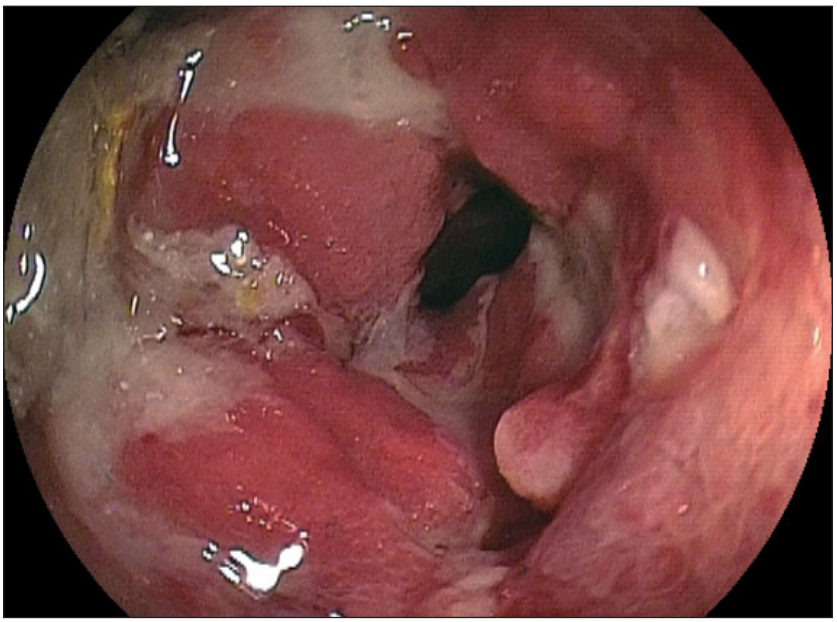

Fig. 13
Coeliac disease with T-cell lymphoma (the same patient as seen on the Fig. 12). The remnants of the fruit were flushed out. Swelling nodulated mucosa with ulcers inside the stenosis.

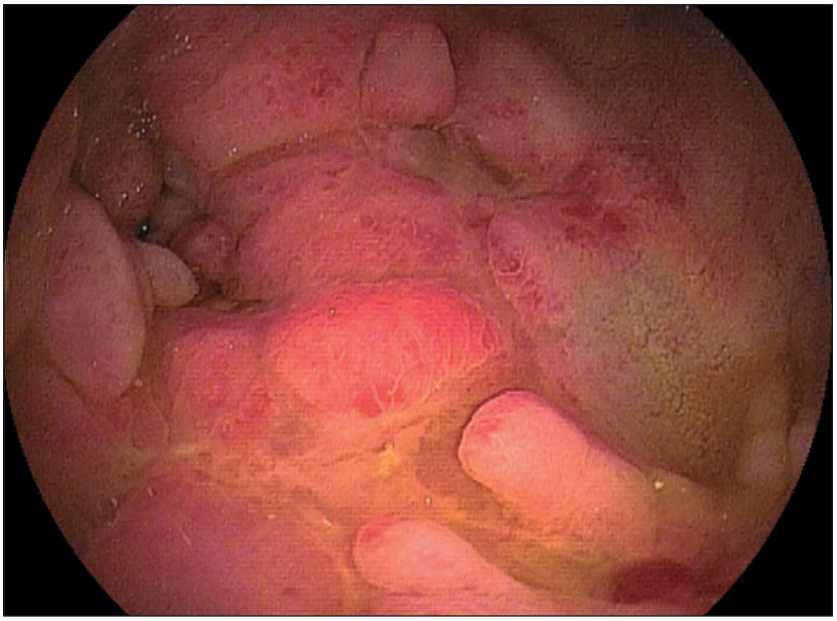

Fig. 14
Crohn's disease. Tight jejunal inflammatory stenosis with deep ulcers and inflammatory polyps.

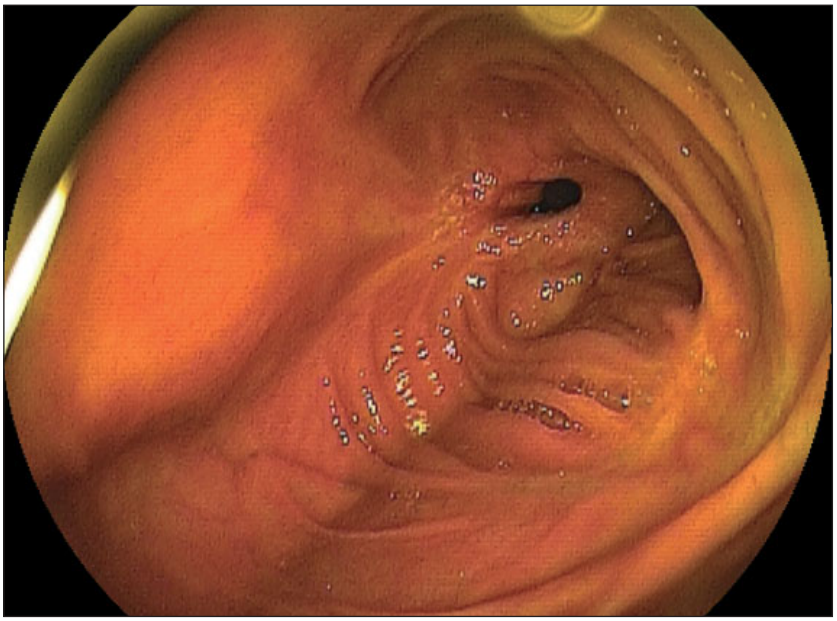

Fig. 15
Crohn's disease. Tight fibrotic stenosis of the jejunum.

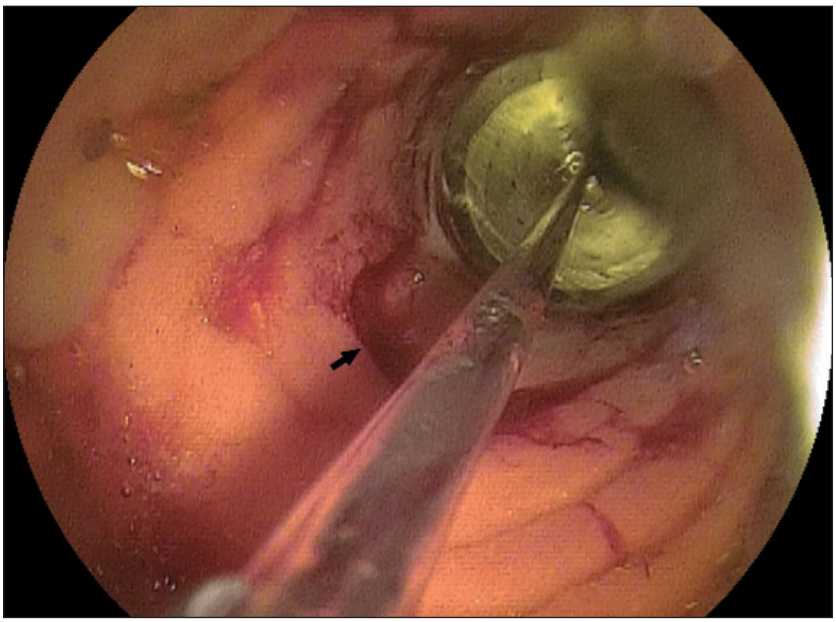

Fig. 16
Crohn's disease. Balloon dilatation of tight jejunal fibrotic stenosis (the same patient as seen on the Fig. 15). The view inside the dilatation balloon (the endoscope is tight to the balloon, water immersion is present between the scope and balloon for it to be possible to follow the course of dilatation). The wire going through the balloon is seen in the middle of the bowel lumen. Small laceration of the mucosa is marked with an arrow.

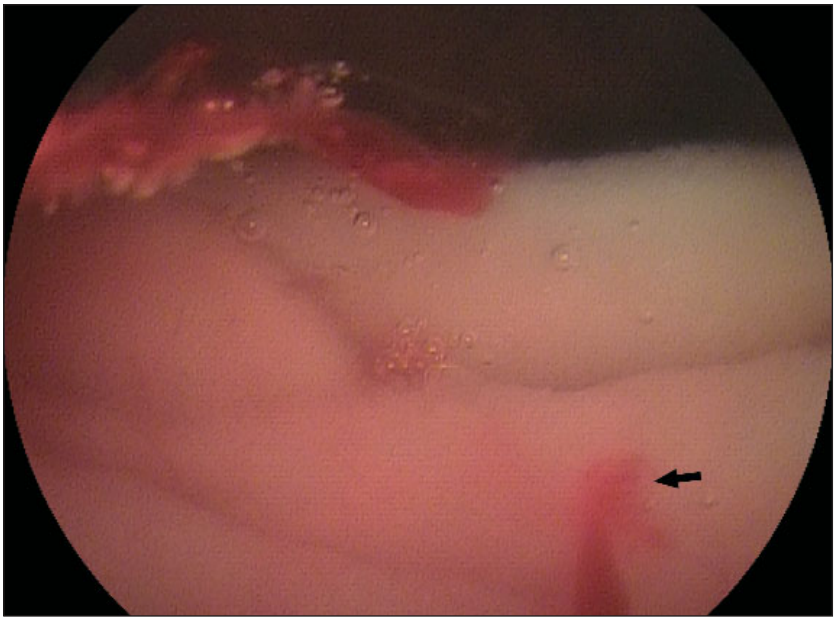

Fig. 17
Arteriovenous malformation (arrow) in the jejunum with small stream of oozing blood.

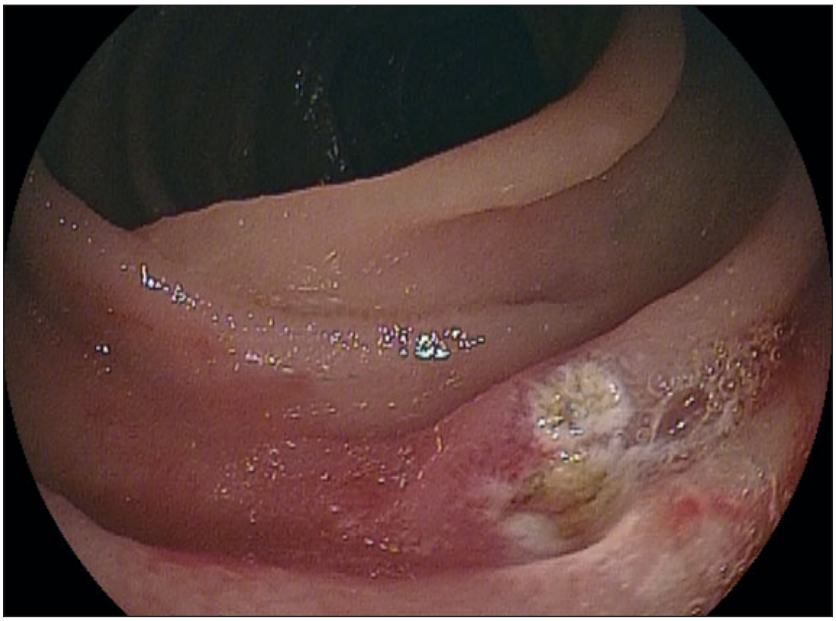

Fig. 18
Arteriovenous malformation (the same patient as seen on the Fig. 17) after argon plasma coagulation.

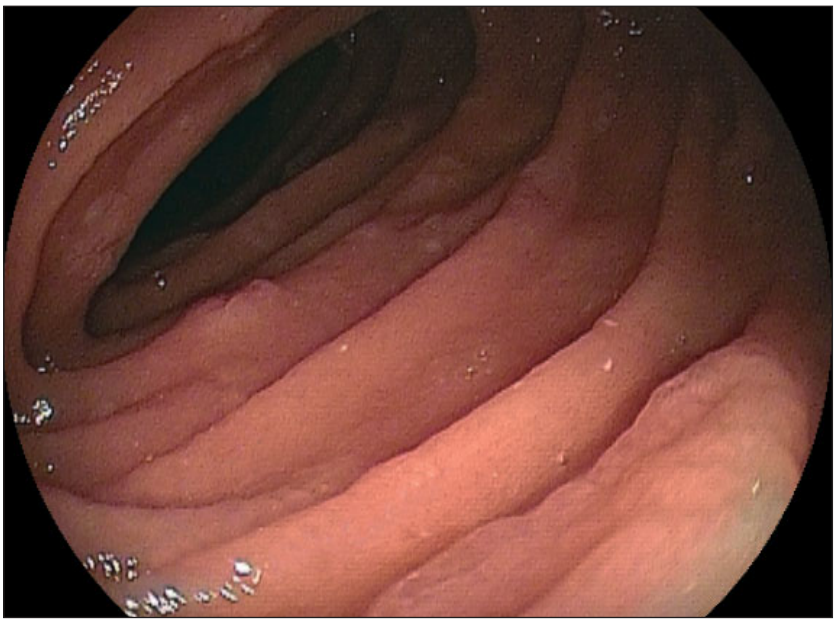

Fig. 19
Familial adenomatous polyposis. Multiple flat adenomatous polyps in the jejunum.

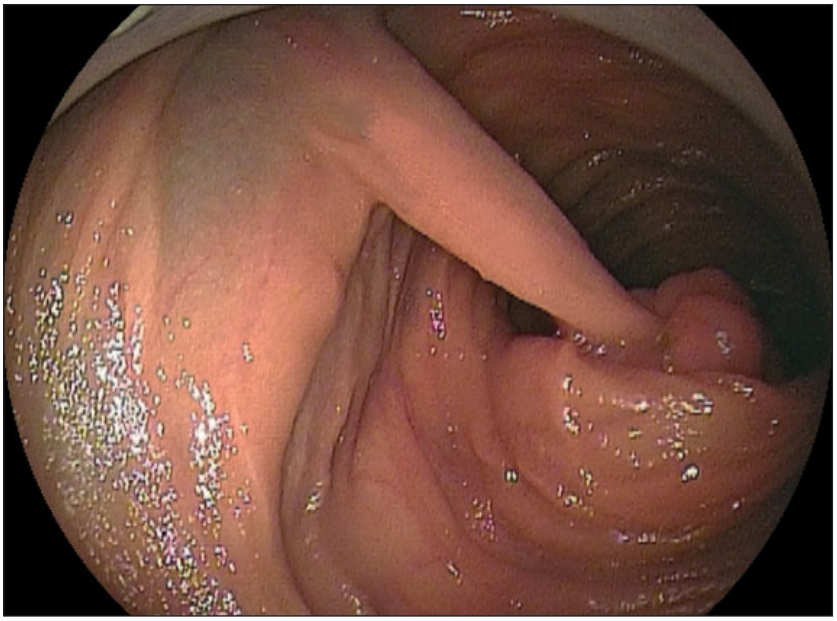

Fig. 20
Peutz-Jeghers syndrome. Stalked hamartoma in the jejunum.

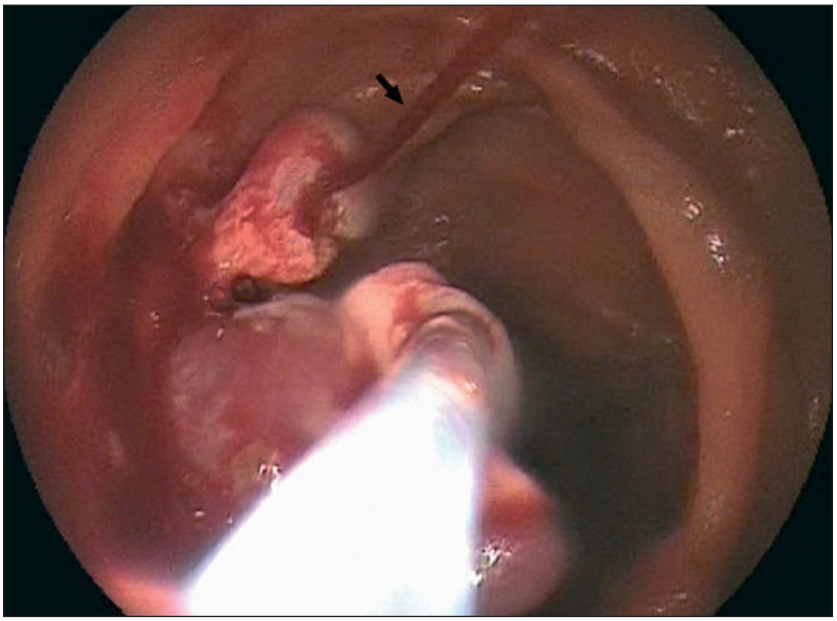

Fig. 21
Peutz-Jeghers syndrome (the same patient as seen on the Fig. 20). Polypectomy was complicated with spurting bleeding. The jet of the blood is marked with an arrow.

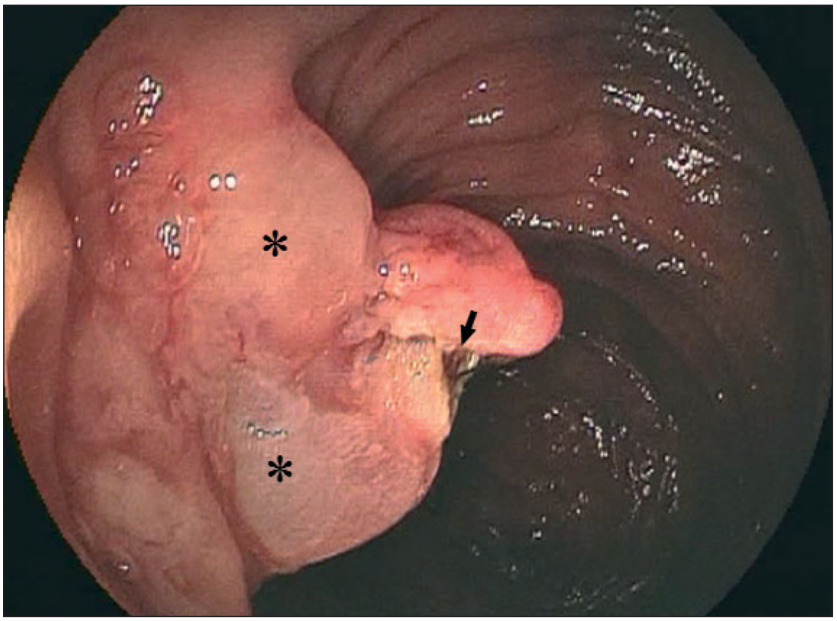

Fig. 22
Peutz-Jeghers syndrome (the same patient as seen on the Figs. 20 and 21). The bleeding was solved by immediate interception of the bleeding stalk by the polypectomy snare with following coagulation of the stalk. The base of the polyp was injected with epinephrine solution afterwards (asterisks), the coagulated part of the stalk is marked with an arrow.

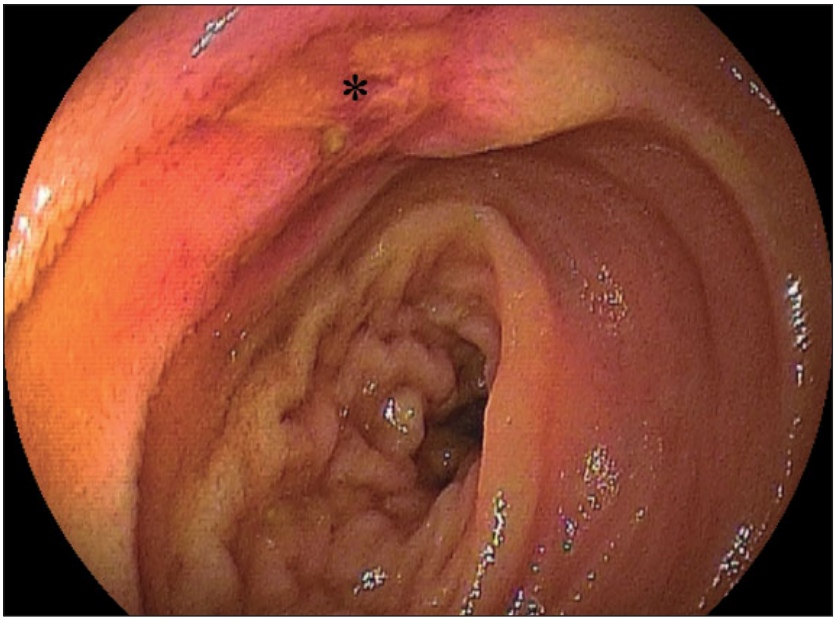

Fig. 23
Solitary ulcer in the oral ileum (asterisk) caused by NSAIDs. The base of the ulcer is covered by fibrin.

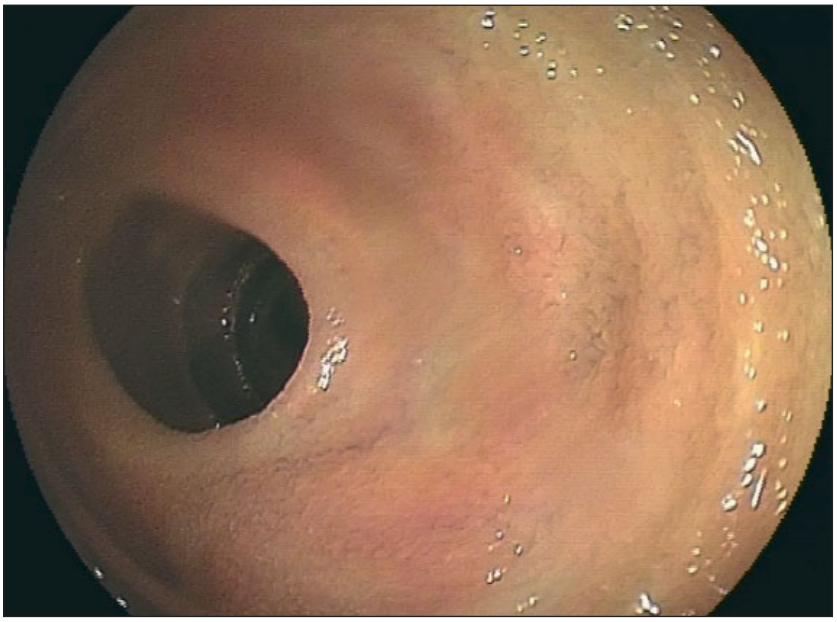

Fig. 24
Diaphragm-like stenosis caused by NSAIDs. Normal Kerkring's folds are seen behind the stenosis.

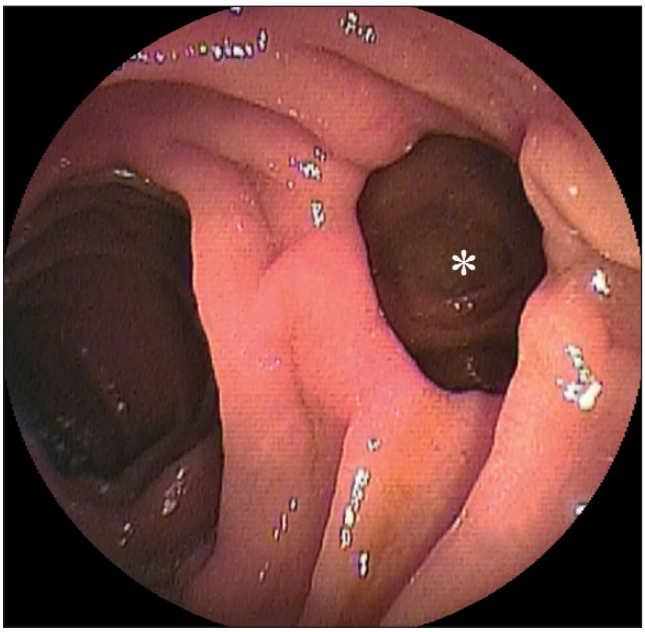

Fig. 25
Jejunal diverticulum (asterisk).

slowly coagulated by pure coagulation current. Later there were no sings of bleeding in this young patient (Figs 20-22).

Discussion

This study presents our results and initial experience with the first fifty DBEs in a single tertiary centre in the Czech Republic. We succeeded in visualizing the entire small bowel by DBE in 4 of 42 oral DBEs (9.5 %) in one session. We consider it to be very good

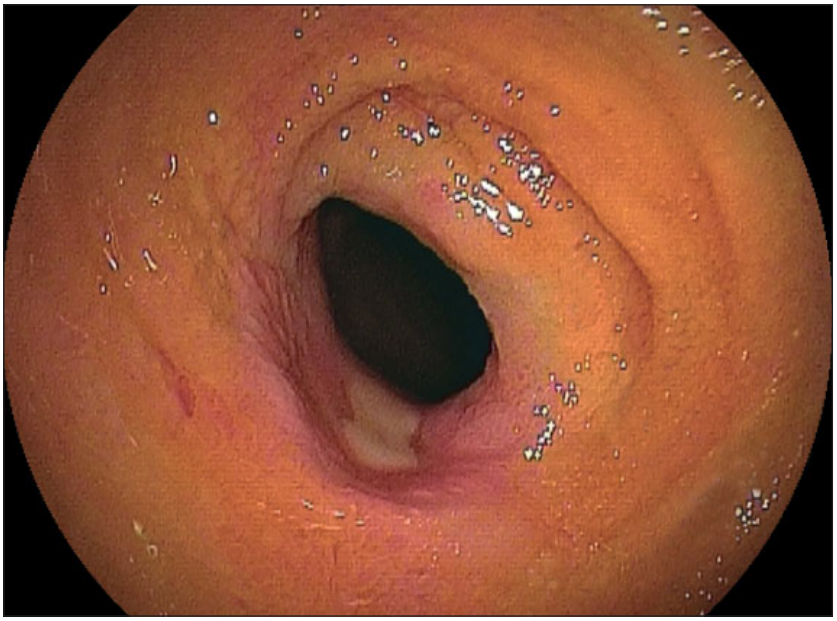

Fig. 26
Post-irradiation ulcer in the proximal ileum with mild stenosis. The base of the ulcer is covered by fibrin membrane.

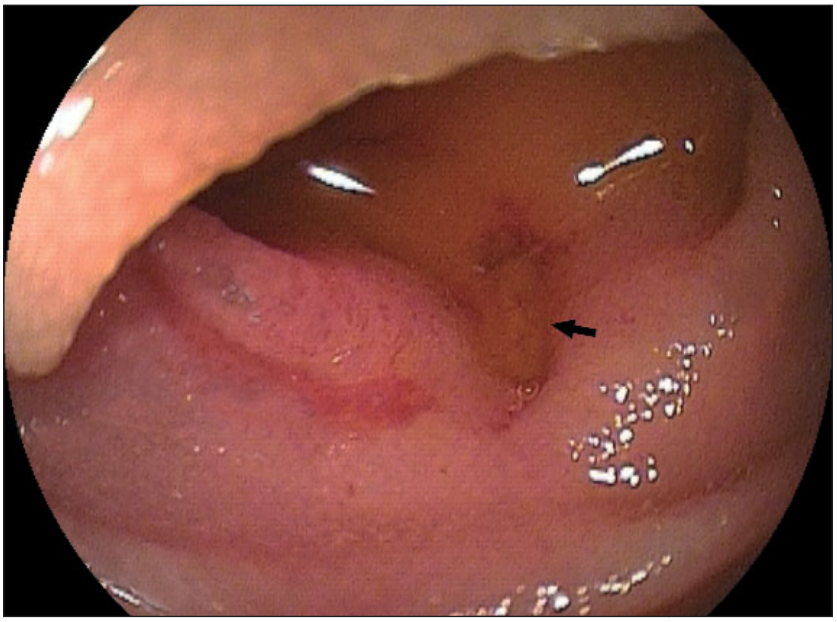

Fig. 27
ERCP using double-ballon endoscopy. Stenosis of the choledochojejunostomy (arrow).

result, because total enteroscopy is not usually achieved using the oral route alone. It is possible in rare cases according to the literature available (15). In a large German study it was possible only in two of the 137 patients, i.e. in 1.5 % (15) and in Yamamoto's series only in two of the 123 patients, i.e. in 1.6 % (7,23). The strategy of combining the oral and anal approaches for DBE allows total enteroscopy more often (15). To achieve this, the deepest point reached during the peroral procedure is marked by mucosal injection with Indian ink (Fig. 8), so that the same mark can be reached again from the anal route. In a large Dutch study the figure was 42 patients out of total 275 subjects, i.e. 15 % (8). We indicated this combining approach in 4 of our patients, but we did not succeeded in panenteroscopy in any. In two of them we failed to intubate terminal ileum (No. 44 and 46) and in the others we did not reach the tattooing (because of intestinal adhesions – No. 45 and 50). The anal approach seems to be more difficult and our learning curve is too short. However, total enteroscopy is only necessary in less than half of the patients (15). In our series it was 9 patients (18 %).

DBE could be difficult after previous abdominal surgery because of small intestinal adhesions. Only 17 of our 50 DBEs were performed in patients with negative history of major abdominal surgical intervention. We did not observe any substantial differences between these two groups. Only in three cases we did interrupt the procedure due to presumptive adhesions (the scope did not move far into the small intestine in a few consecutive cycles). Surprisingly all of our four patients with total oral enteroscopy were numbered among after-surgery group.

The main indication for DBE was suspected small-bowel bleeding. As in other studies, the bleeding was mostly caused by angiodysplasias (8). A predilection for angiodysplasias was found in the proximal jejunum, in one patient only (No. 43) in the distal ileum.

Crohn's disease was the second most frequent indication for DBE by both, diagnostic or therapeutic reason (Figs 14-16). There are some reports of capsule endoscope retention in the literature, range from 0.75 to 10 % of cases (2,4,5,18,19). Surgical retrieval of the capsule with simultaneous solving the cause of retention (mostly stenoses) was the only possibility before the era of DBE (4). DBE allows us to manage both the problems by endoscopic manner: to dilate the stenosis and retrieve the capsule (see Table 1, patient No. 4, consecutive dilatations of five stenoses No. 9, 17, and 32). Similar case reports have been published recently (1,13,16).

The third frequent indications for DBE are small intestinal polyps. The method has chiefly been used in patients with Peutz-Jeghers syndrome, an inherited, autosomal dominant disorder characteristic in those hamartomatous polyps in the gastrointestinal tract, mostly in the small bowel (small bowel in 78 % of the patients, colon 42 %, stomach 38 % and rectum 28 %) and pigmented mucocutaneous lesions. This syndrome also predisposes the patient to gastrointestinal, pancreatic, breast, uterine, and other malignancies (14,17). During the first three decades of life, bleeding, obstruction and/or intussusception are common complications in patients with Peutz-Jeghers syndrome. Intra-operative enteroscopy had been the only possibility for these patients before DBE-era. The DBE with polypectomies (Figs 20-22) may obviate the need for repeated urgent operations and small bowel resections leading to short bowel syndrome (8,12).

Conclusions

DBE permits endoscopic exploration (and treatment) of the small intestine. The procedure is feasible, safe and useful. DBE has a potential to be a standard of enteroscopy by replacing conventional push-enteroscopy. In the near future, DBE together with capsule endoscopy, will be essential modalities for the management of small intestinal diseases. Intra-operative enteroscopy remains the method of choice for those patients, in whom complete small bowel enteroscopy is indicated, but not possible by means of DBE, or the lesions are multiple and transmural (not possible to solve by endoscopy or surgery alone). An endoscopic centre specialized in small bowel diseases should have all of these three methods available.

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