X-Ray Contrast Presentation of the Thoracic Duct by Enterally Resorbed Iodized Oil Emulsions in Cats and Dogs

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Iodized oils have been used in two completely different fields of clinical medicine:

1. Fat resorption tests as a diagnostic approach to pancreatic disorders (e.g. Lipiodol test of *Trémolière* [1]). The amount of resorbed fat may be assayed by quantitative iodine analysis.

2. Direct lymphography. This method has proved suitable especially for peripheral lymphatics and lymph node presentation. It may also be used to demonstrate the thoracic duct. It is inconvenient, however, and direct lymphography with high doses (20–40 ccm contrast medium) comprises a relatively high rate of complications (2).

In a number of experiments in cats and dogs we tried to combine the above modes of application in order to achieve contrast presentation of the thoracic duct with a physiologic approach.

The findings reported here comprise the combined results of two series of tests, the first conducted between 1966 and 1968 in cats (see also 3, 4) and the second in 1968 and 1969 in dogs (5). We intend to give a critical evaluation and comparison of the different methods used to provide sufficiently high concentrations of contrast medium in thoracic duct lymph by means of increased or accelerated enteral resorption.

Material and Methods

The investigations were performed on 5 young cats (average weight 1.5–2.5 kg) and 9 dogs (average weight 24 kg). Three of the dogs were gastrectomized animals. Some of the animals were given an experimental trial up to 4 times. The cats were anesthetized by intraperitoneal administration of 30 mg/kg body weight of Hexobarbital, the dogs by intramuscular injections of Dolcontral (Pethidin 50 mg) and Sinophenin (Rodleben, = Promazin 20 mg). No atropin was used with respect to its inhibitory action on gastrointestinal motility and absorption. The contrast medium was applied through a stomach tube. Prior to and following the experiments the dogs obtained 5 ml of 40% $NaCl\,O_4$ and 20 µg Trijodthyronin to avoid iodine intoxication.

The following iodized oils were generally used in cats and moreover in two experiments in dogs: Lipiodol (Guerbet), Jodipin (Merck), Jodolipol (Medexport). They were emulsified and mixed together with Lipase (Fluka) and Biliton (Berlin-Chemie) or

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Cholecysmon (SSW) – both dehydrocholic acid preparations with choleretic and cholagogic effects –, and tragacantha. These drugs were given in various concentration ratios; the following mixture has proved to provide good results:

(1.) Iodized oils (30–40% w/w iodine) 10.0; Lipase 0.15; Cholecysmon 0.15; tragacantha 0.5. The quantity of emulsion which was administrated in one experiment was planned to achieve an iodine application of 2–5 g J/kg body weight in cats and up to 1 g J/kg in dogs.

In a second series of experiments we exclusively used preparations of Lipiodol Ultrafluid (Byk-Gulden) mixed and emulsified by means of different kinds of oil-water emulsifying agents, mainly "Lanette-Wachs AH" (Rodleben). The size of particles was measured microscopically as within a range of 0.05 to 1 μm, mostly between 0.2 and 0.8 μm. Best results were obtained by the following mixture:

(2.) Lipiodol UF 30%; Lanette-Wachs AH 1.5%; aqua ad 100%.

Details on other prescriptions used and methods were given elsewhere (4, 5). Both experimental series were preceded by in-vitro-experiments to investigate the rate of hydrolytic cleavage and the dispersion size of the emulsified particles, respectively.

Roentgen-techniques: 6-valve apparatus (TUR Dresden). Experiments in cats: 80 kV, 2 m A/sec. The first picture was taken 1 h following application of contrast medium; 3 further exposures at one-hour-intervals, then at 6-hour-intervals up to 24 hours. Experiments in dogs: 80 kV, 100 mA; 0.2 sec. The first picture was taken after 30 min, the following at identical intervals as in cats. Zonography was performed by the usual techniques applied in man.

Results

1. Experiments of the first series: Emulsions according to the prescription (1.) remained in the stomach only for ½ h. After 4 h most of the X-ray contrast had passed the jejunum and ileum. A minor part of the contrast medium which had escaped absorption was found in the colon. After 8–10 h only small amounts of contrast medium were left in the lower parts of the colon and in the rectum. Further observations on the intestinal passage are published elsewhere (4).

In dogs intestinal transit was not as fast as in cats. It took 6–8 h and the major part of the contrast medium appeared to reach the colon. The gastrectomized dogs showed an accelerated intestinal passage (3–5 h); the roentgenological density of the contrast remained fairly unchanged during the passage.

In cats the thoracic duct could be seen on the films taken one to ten hours after administration of contrast medium. It appeared as cord-shaped density of 3–4 cm length and 2–3 mm width projected over the upper part of the lumbar and the lower part of the thoracic vertebral column (Fig. 1). Similar contrast shadows were never seen on any control exposures. However, neither a distinct delineation of intestinal lymphatics and cysterna chyli nor visualization of the upper part of the thoracic duct could be achieved, even though filled lymphatics were visible during direct examination at laparotomy. In dog experiments the cysterna chyli was demonstrable with faint contrast by means of the same technique as used in cats.

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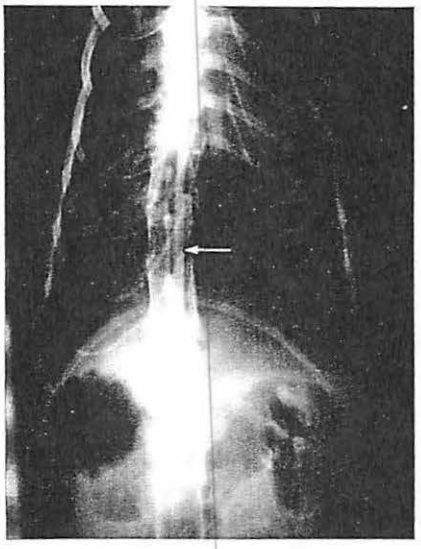


Fig. 1

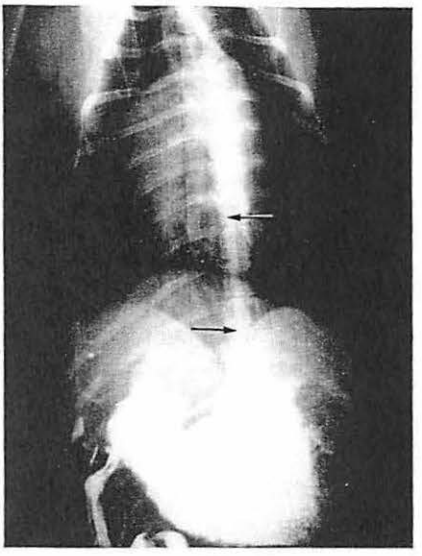
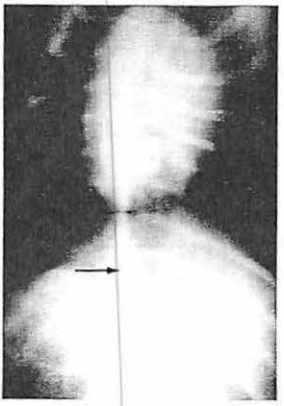


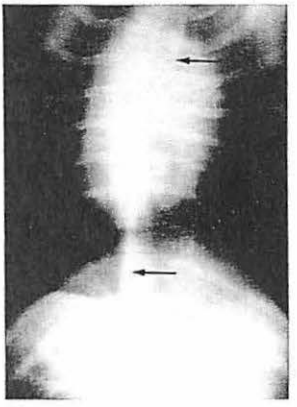
Fig. 2

Fig. 1 Contrast presentation of the thoracic duct in the cat by lipolized iodized oil emulsion.
Fig. 2 Contrast presentation of the thoracic duct in the dog by small size particle emulsion.

2. Experiments of the second series: The course of the gastrointestinal transit of contrast medium (according to the prescription [2.]; 0.5–1.0 g iodine/kg body weight) was very similar to that of the above experimental series. After 30 h no traces could be observed within the alimentary canal. X-rays 3½ h following administration of contrast material showed a cord-shaped density of 6 mm width which ran paravertebrally from the 11th to the 6th thoracic vertebral body (Fig. 2). The density increased up to the 6th hour and then remained constant for several hours. Even though 20 to 24 hours later still some contrast could be observed in the distal parts of the colon and the sigmoid the



a



b

Fig. 3 Zonography of the caudal (a) and the cranial (b) part of the thoracic duct in the dog (same procedure as in Fig. 2; see text).

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shadow suggestive of the thoracic duct remained visible. – Ventrodorsal zonography showed that the contrast was situated in a depth of 6 cm in its caudal section (Fig. 3 a) and 8 cm in its cranial part (Fig. 3 b). As in the first experimental series the contrast was discernible in none of the control pictures. In lateral views it was not as clearly discernible as in anterior-posterior or oblique projections.

Toxic reactions and complications: In both experimental series only one of the cats and none of the dogs showed symptoms related to enteral application of the described contrast media: following a second administration within a two month period a severe but transient iodine-catarrh of several mucous membranes occurred. – One cat was lost because of aspiration of contrast medium during anesthesia which was followed by pneumonia. – Some findings concerning the fate of the enterally administered iodine and its elimination have already been published (4).

Discussion

In dogs determination of the topographical localisation of the contrast presumably located within the thoracic duct could be performed by means of zonography. This demonstrated identity with the thoracic duct as described in text-books of topographical anatomy (6). Moreover we used for comparative purposes the descriptions and pictures which have been made by direct lymphography, i.e. cannulation of abdominal lymphatics, in cats (7) as well as in dogs (8). In both animal species our interpretation appeared correct.

Comparative results on the enteral passage of lipiodol in a nonemulsified form were given by *Groen* (9). A substantial increase in the rate of absorption of emulsified iodized oils in comparison to nonemulsified was observed by *Pansdorf* (10) as early as 1927. Thoracic duct contrast presentation by enterally absorbed iodized oils have been observed by neither of the two authors and has, as far as we know, not been reported as yet. Attempts to visualize the intestinal lymphatics by this method as mentioned by *Nusbaum* et al. (11) did not yield results.

The delaying and inhibitive influence of anesthesia especially in dogs may be the cause of retention of considerable amounts of contrast medium within the large intestine. This is in accordance with *Bollman* et al. (12) who published similar observations on inhibited intestinal absorption in anesthetized rats. – The slight or lacking contrast of the cranial portion of the thoracic duct may sufficiently be explained by dilution of "milky" intestinal lymph with fat-free "water-clear" liver lymph conveyed by the hepatic duct (4). – The lack of distinct contrast in lateral views in the dog may be due to the flat-oval shape of the thoracic duct and moreover to its projection on the aortic shadow and the anterior part of the vertebral bodies (5, 6).

During the first experimental series attempts to increase absorption by using the ethanol esterified Lipiodol UF have failed (for details see [5]). We were successful, however, by using glycerol esterified physiologic oils treated in the same manner as Lipiodol UF, i.e. in a digested hydrolysed form. Therefore it is suggested that the different results in the two series are partially due to chemical differences between glycerol and ethanol esterified iodized fatty acids.

In the second series of investigations the long persistance of the contrast of the thoracic duct – even when the small intestine was already empty of the Lipiodol UF-emulsion –

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was quite unexpected. Protracted release of the contrast material from the mucosal epithelial cells into the intestinal lacteals – mainly because of metabolic convertion processes – may be assumed. Besides, absorption from even lower parts of the bowel, i.e. caecum and colon, could provide another explanation, though absorption of "normal" lipids generally is accepted to be limited to the small bowel (13, 14). Information on the fate of such nonglycerol esterified "artificial" lipids as Lipiodol UF in the different parts of the alimentary tract seems to be lacking. Digestion and absorption of normal lipids and "persorption" of whole nondigested particles, however, could provide a sufficient theoretical basis for our findings (12–15).

The encouraging results give rise to the assumption that further improvement of the methods may lead to an even increased absorption and thereby better contrast presentation of the thoracic duct.

Summary

A report ist given on experiments to provide a contrast presentation of the thoracic duct by means of emulsions of iodized oils absorbed from the intestine in cats and dogs. In a first series of experiments attempts were made to reach the above aim by means of predigested (by lipase and cholic acid preparations) glycerol esterified iodized oil emulsions. The results were fairly satisfactory but the requirement for high doses (1–5 g iodine/kg body weight) gave rise to start another series of experiments which was theoretically based upon the supposition that extremely small sized droplets of lipids may be "persorbed" entirely, i.e. without previous hydrolytic digestion. Best results could be thus achieved by means of a Lipiodol UF-emulsion, using only 0.5–1.0 g iodine/kg. Except for one case of iodine iodiosyncrasy no side reactions could be observed in both series of experiments.

Acknowledgements

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