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OLEOFERROTRAST, A RADIO-OPAQUE MAGNETIC MEDIUM: ITS RADIOSPECIFICITY AND TOXICITY

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Artificial contrasting of organs and systems with the aid of substances absorbing x-rays is a technique used in nearly every branch of clinical medicine. Water-soluble and oily radio-opaque substances (ROS) containing iodine, and an aqueous suspension of barium sulfate are the most widely used in medical practice. Despite their many positive properties these substances have one common failing: when introduced into the body they undergo physiological processes linked with the blood and lymph flow and the contractility of hollow organs, and they cannot be stored for the necessary length of time in the region of concern to the investigator. One way out of this difficulty is to create a new class of ROS containing magnetic substances in their composition.

In the scientific literature there are publications devoted to magnetic ROS and attempts to contrast various organs and systems with them [2-6].

Disadvantages of known radio-opaque magnetic media include the possibility of absorption of the carrier liquid in a hollow organ during contrasting and their low stability with time in gravitational and magnetic fields because of the large particle size.

The aim of this investigation was to obtain and study the possibility of using a magnetic ROS on an oily base to contrast various hollow organs under experimental conditions, and possessing the following essential qualities: pharmacologic inertia, i.e., harmlessness for the recipient; chemical and physical stability; a high degree of dispersion; homogeneity; sufficient saturation magnetization to be directed by an external magnetic field; optimal viscosity and optimal radio-opacity. We studied the physicochemical and radiospecific properties of a newly developed preparation, conventionally called oleoferrotrast.

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TABLE 1. Dependence of Viscosity of Ferromagnetic Liquid on Its Magnetization

Magnetization, kA/m	Viscosity, Ps
18	6,83
20	7,09
23	8,97
26	11,15
32	15,45
38	34,12

TABLE 2. Dependence of Radio-Opacity of Oleoferrotrast on Saturation Magnetization (myodil and an aqueous suspension of barium sulfate were used as standards)

Saturation magnetization, kA/m	Degree of radio-opacity compared with	
	myodil, %	aqueous suspension of barium sulfate, %
20	86	87
32	94	97
38	97	99

TABLE 3. Dependence of Radio-Opacity of Oleoferrotrast on Saturation Magnetization (standard preparation lipiodol)

Magnetization, kA/m	Degree of radio-opacity compared with lipiodol, %
33	79±5
41	91±5
46	113±5
56	118±5

EXPERIMENTAL METHOD

The magnetic radio-opaque substance was obtained by a chemical method in the laboratory (author's certificate No. 1390838). Oleoferrotrast is an oily liquid consisting of magnetite, stabilized in mineral oil by oleic acid. The technology of obtaining oleoferrotrast consists of mixing aqueous solutions of salts of bivalent and trivalent iron with a solution of ammonia, washing the resulting residue with distilled water, and dispersing it in a solution of oleic acid in mineral oil. Next water is removed from the resulting pasty mass and it is diluted with mineral oil to the required concentration of magnetite. The saturation magnetization of the magnetic liquid is tested on a BU-3 apparatus by a ballistic method, based on measurement of the shift of magnetic flux in the sample during a change of magnetic field.

The dynamic viscosity of oleoferrotrast was measured by means of a standard "Reotest-2" coaxial-cylindrical viscosimeter. Radio-opacity was estimated by comparative densitometry, taking the opacity of a standard preparation to be 100%. The density of blackening of the roentgenograms was measured with a MF-4 microphotometer. The standards were myodil, an aqueous suspension of barium sulfate, and lipiodol.

As the sources forming the external magnetic field for holding and moving the oleoferrotrast in hollow organs, an electromagnetic with magnetic field intensity in the gap of 330 kA/m and a permanent samarium–cobalt magnet with magnetic field induction on the surface of 0.4 Tl were used.

Fig. 1

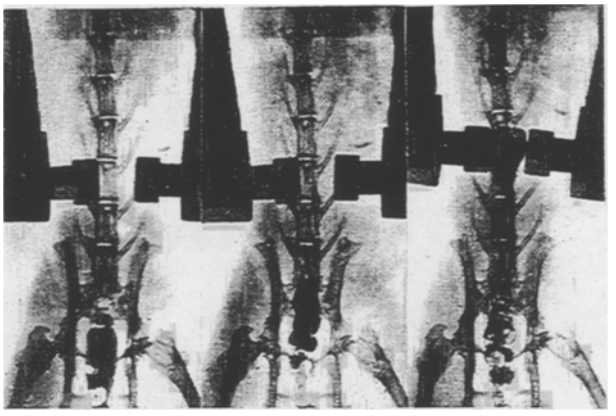

Fig. 2

Fig. 3

Fig. 1. Videomagnetic recording at time of retention of oleoferrotrast in rabbit esophagus under the influence of an external magnetic field.

Fig. 2. Roentgenograms of rectum of a rabbit after injection of oleoferrotrast: proximal part of rectum immediately after injection of material, displacement of column of contrast material in cranial direction to middle of alae of iliac bones, column of contrast material at level of magnetic poles.

Fig. 3. Videomagnetic recording of rabbit urinary bladder during contrasting of its neck with oleoferrotrast, and with an external magnetic field source.

The radiospecific properties of oleoferrotrast were studied on noninbred mice, rats, and chinchilla rabbits. The roentgenologic investigations were carried out on a "Chirodur-125-B" apparatus. For a more detailed analysis of the behavior of oleoferrotrast in hollow organs, x-ray television was used. The kinetics of the substance in the gastrointestinal tract was studied by comparison with the traditional material, namely barium sulfate. The magnetic radio-opaque substance was injected in a volume of 10-60 ml. For cystography, metrography, and irrigoscopy, the volume of oleoferrotrast injected was 0.5-5.0 ml.

EXPERIMENTAL RESULTS

Analysis of the results showed that the saturation magnetization of oleoferrotrast varies from 30.0 to 37.0 kA/m, its viscosity from 13.0 to 20.0 Ps; its radioopacity relative to myodil 76.5%.

Table 1 gives the results of a study of viscosity of the test radio-opaque substance depending on its magnetization. It was shown that the viscosity of oleoferrotrast increases with an increase in its degree of magnetization It was also shown that the radio-opacity of oleoferrotrast increases with an increase in the degree of magnetization (Tables 2 and 3). The radio-opacity of the samples obtained was determined when the content of magnetite by volume was increased.

The stability of the magnetic liquid was studied by centrifugation at 2500-3000*g* for 30 min, and also at 6000*g* for 5 h. The magnetic liquid did not separate into layers, but ultimately some degree of sedimentation of magnetite particles was noted. The magnetic liquid did not separate into layers likewise when kept for 2 years.

On introduction of the substance into the gastrointestinal tract the dynamics of its onward movement without exposure to an external magnetic field basically did not differ from the kinetics of barium. Only along the large intestine was the passage of the radio-opaque substance more rapid, due to the relaxing action of the mineral oil. During exposure to an external magnetic field, the behavior of the oleoferrotrast differed in character. A characteristic feature during investigation of the esophagus was an effect of long delay of the contrast material in the zone of the highest magnetic field gradient. This persistent opacity enables not only the roentgenomorphologic features of the esophagus, but also its contractile function, to be studied, and this will undoubtedly find practical application in clinical practice.

During an investigation of the small intestine the best results were obtained in the diagnosis of obstruction due to adhesions.

In cases of irrigoscopy a distinguishing feature of magnetic x-ray contrast investigation of the large intestine was an effect of retrograde and anterograde movement of oleoferrotrast by means of an external magnetic field (Figs. 1, 2, and 3).

During cystography, oleoferrotrast under the influence of the external magnetic field was easily concentrated in any part of the bladder.

The study of acute and chronic toxicity of the preparation showed [1, 3] that it has virtually no side effects on the recipient. The lethal dose of oleoferrotrast for mice, when given by intraperitoneal injection, averaged 250 ml/kg body weight. During long-term observation on rabbits and rats no disturbances either of the parameters of the animals' physiological state or of the blood and urine analyses were found.

It can be concluded that the synthetic magnetic radio-opaque substance is nontoxic and stable and possesses sufficient radio-opacity for undertaking special roentgenologic investigations. Oleoferrotrast can serve as the basis for development of a medicinal form suitable for clinical application.

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