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INGRID RÓŻYŁO-KALINOWSKA, EWA SZCZEPANIK-BARCZEWSKA,
MAŁGORZATA DENKOWSKA, ŁUKASZ BARCZEWSKI

Ultrasonographic patterns of iatrogenic foreign bodies in the in vitro study

The presence of foreign bodies in soft tissues may lead to their swelling and development of inflammatory processes. Frequently inflammatory reactions are the cause of spontaneous elimination of the foreign body from the tissues in the course of healing processes. However, the doctor cannot rely on spontaneous resolution of the condition and precise diagnostics as well as adequate treatment measures must be applied. Sometimes foreign bodies are detected clinically, especially when they are large or superficially located. Nevertheless, in detection and localisation of foreign bodies in soft tissues generally considerable diagnostic difficulties are encountered (4, 5). Conventional radiography remains the basic diagnostic technique, but is effective only in cases of foreign bodies composed of radiopaque materials. Objects that are radiolucent or poorly radiopaque are invisible or only slightly visible, which often makes the result of radiological study falsely negative (4, 5, 6). Computed tomography (CT) or magnetic resonance imaging (MRI) are very efficient in diagnostics of such cases but these advanced imaging modalities are expensive and not always available. On the contrary, ultrasonography is a widely available and cost-effective examination. Therefore, the purpose of the study was a trial of application of ultrasonography for description of imaging patterns of iatrogenic foreign bodies in an *in vitro* model.

MATERIAL AND METHODS

Examples of radiolucent and poorly radiopaque foreign bodies such as plastic fragments of syringes, needles for injections, intravenous catheters, different cotton and gauze swabs, were embedded in containers filled with gelatine, which served as a model of soft tissues as well as played the role of a stand-off pad. The ultrasound scanning was performed by means of ATL HDI 3500 machine with a high-frequency broadband linear transducer. There was determined the possibility of detection of various types of foreign bodies. Ultrasonographic image patterns of different objects including echogenicity and produced artifacts were described.

RESULTS

All types of used materials were well visible and hyperechoic in ultrasound image (Figs. 1–3). Plastic objects caused appearance of numerous reverberation artifacts (Figs. 1, 2). Generally, the shape of upper surfaces of plastic objects such as parts of syringes, needles or intravenous catheters could be recognized. The swabs produced characteristic patterns of internal structure corresponding to several

folds of gauze building the swab (Fig. 3). Air bubbles trapped between the folds of gauze contributed to appearance of more strongly hyperechoic spots distributed within the swab. Variations in ultrasonographic image patterns of foreign bodies studied *in vitro* allowed differentiation of various types of the examined materials.

Fig. 1. Plastic part of an intravenous catheter – the upper surface is hyperechoic and its shape recognizable. There are visible reverberation artifacts

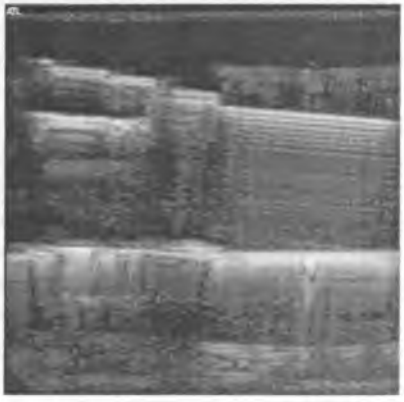

Fig. 2. Injection needle – fairly well recognizable shape of the object, numerous reverberation artifacts produced by plastic and metallic parts of the needle

Fig. 3. Hyperechoic swab composed of many layers of gauze with more hyperechoic spots corresponding to air bubbles trapped in the interior of the swab

DISCUSSION

Foreign bodies of iatrogenic origin may rarely remain undetected during surgery or in emergency situations (6). Such cases tend to be infrequently reported in literature because of legal implications connected with non-anticipation and misdiagnosis (9). Foreign bodies may produce complaints or sometimes are an accidental finding on a radiogram. When the presence of a radiopaque foreign body is suspected, radiological examination is indicated (4). The issue of soft tissues foreign bodies being a iatrogenic complication and above all of their radiological patterns is not widely discussed in nationwide literature. There are reported mainly cases of iatrogenic presence of dental filling materials in alveolar processes or in maxillary sinuses (10, 11) but these materials usually are radiopaque and well visible in conventional radiography. However, radiolucent or poorly radiopaque foreign bodies made of plastic may cause false negative results of radiographic examination.

The complaints produced by foreign objects present in soft tissues may mimic neoplasms and result in prescribing costly CT or MRI examinations, especially when inflammatory processes accompanying foreign bodies cause osteolytic or osteoblastic reactions in underlying bones (7). Then again ultrasonography is less costly and more available than advanced imaging modalities so it may be an initial step in a diagnostic procedure.

In own material all objects used in the *in vitro* study were well visible in ultrasonography and their upper surfaces were hyperechoic. Plastic as well as metals (for example metallic parts of needles or intravenous catheters) produced reverberation artifacts and this finding corresponded to our previous studies (12). Contrary to observations of other authors (5) no acoustic shadowing could be detected in cases of plastic, which also was consistent with other own *in vitro* studies on plastic objects of different shapes and sizes (12). According to some authors (6) the presence of ultrasonographic artifacts depends rather on surface attributes than the composition of the foreign body. Smooth and curved surfaces produce reverberations and acoustic shadowing, while smaller curvature accounts for lack of reverberations. Other authors (13) state, however, that the presence or lack of acoustic shadowing is related to the direction of angle of ultrasonographic beam.

Ultrasonography depicted shapes of the studied objects so they could be recognized on the basis of the images. This was true also for gauze swabs that produced characteristic patterns of internal structure corresponding to several folds of gauze. On the other hand, absorption of blood by surgical sponge and the presence of inflammatory reaction change its appearance and characteristic ultrasound pattern may not be visible, and instead the so-called gossypiboma pseudotumor is formed (9).

In vitro conditions are of course always only a model and in clinical situations the presence of haematomas, calcifications, connective tissue scars or air bubbles may hamper diagnosis and produce falsely positive results as these conditions generate strong echoes that may be recognized as foreign bodies (6). Moreover, placement of exemplary foreign bodies in containers filled with gelatin allowed different orientations of sonographic probe and in clinical conditions it is not always possible to direct ultrasonic probe exactly perpendicularly or parallelly to the examined object (6).

CT examination is considered an alternative in visualization of radiolucent or poorly radiolucent foreign bodies. It must be remembered that although this imaging modality is excellent in presentation of foreign objects as well as inflammatory reactions caused by them, it should be reserved for complicated cases as it is not yet widely available and ionizing radiation burden to the patient is considerable (6). Moreover, some authors (2, 3, 6) proved that in cases of traumatic radiolucent foreign bodies sensitivity of ultrasonography overpasses the sensitivity of CT.

Ultrasonography may become part of the diagnostic algorithm in cases of localization of iatrogenic foreign bodies otherwise invisible in conventional radiography as it is widely available, non-invasive, cost-effective and highly sensitive (2, 6). Sensitivity of ultrasonography depends on foreign body size

and it ranges from 86 to 95% (6). Availability of ultrasonographic equipment in operating theatres may help in intraoperative localization and extraction of foreign bodies (1, 4, 6). It is not an uncommon situation that iatrogenic foreign bodies cause complaints in a longer time period from initial surgery or medical intervention. Ultrasonography is even more efficient in such cases as it allows not only observation of the foreign body, but it enables visualization of soft-tissue inflammations and abscess formation, as well (5, 8, 13).

In conclusion, ultrasonography may become a useful, widely available and cost--effective tool in detection and localisation of foreign bodies of iatrogenic origin that otherwise remain undetected.

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SUMMARY

The purpose of the study was application of ultrasonography for description of imaging patterns of iatrogenic foreign bodies in an *in vitro* model. Examples of radiolucent and poorly radiopaque foreign bodies were embedded in containers filled with gelatine The ultrasound scanning was performed by means of ATL HDI 3500 machine with a high-frequency broadband linear transducer. There was determined the possibility of detection of various types of foreign bodies. All types of used materials

were well visible and hyperechoic in ultrasound image. Variations in ultrasonographic image patterns of foreign bodies studied *in vitro* allowed differentiation of various types of the examined materials. In conclusion, ultrasonography may become a useful, widely available and cost-effective tool in detection and localisation of foreign bodies of iatrogenic origin that otherwise remain undetected.

Wzorce ultrasonograficzne ciał obcych pochodzenia jatrogennego w badaniu *in vitro*

Celem pracy było zastosowanie ultrasonografii do obrazowania ciał obcych pochodzenia jatrogennego w materiale *in vitro*. Przykładowe niecieniujące i słabo cieniujące ciała obce zatopiono w pojemnikach z żelatyną spożywczą i badano głowicą liniową o wysokiej częstotliwości aparatem ATL HDI 3500. Oceniano możliwość wykrywania różnych typów ciał obcych. Wszystkie użyte materiały były hiperechogeniczne i dobrze widoczne w obrazie ultrasonograficznym. Odmienności w obrazie ciał obcych badanych *in vitro* pozwalały na ich różnicowanie. Ultrasonografia może stać się przydatną, szeroko dostępną i tanią metodą wykrywania i lokalizacji ciał obcych pochodzenia jatrogennego.