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Review

Transoesophageal echocardiography in the dog

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ABSTRACT

Transoesophageal echocardiography (TEE) allows imaging of the heart through the oesophagus using a special transducer mounted on a modified endoscope. The proximity to the heart and minimal intervening structures enables the acquisition of high-resolution images that are consistently superior to routine transthoracic echocardiography and optimal imaging of the heart base anatomy and related structures. TEE provides high-quality real-time imaging free of ionizing radiation, making it an ideal instrument not only for diagnostic purposes, but also for monitoring surgical or minimally invasive cardiac procedures, non-cardiac procedures and critical cases in the intensive care unit. In human medicine, TEE is routinely used in these settings. In veterinary medicine, TEE is increasingly used in referral centres, especially for perioperative assessment and guidance of catheter-based cardiovascular procedures, such as patent ductus arteriosus, balloon valvuloplasty, and atrial and ventricular septal defect occlusion with vascular devices. TEE can also aid in heartworm retrieval procedures. The purpose of this paper is to review the current uses of TEE in veterinary medicine, focusing on technique, indications and complications.

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Introduction

The first description of an echocardiographic evaluation through the oesophagus dates from 1976 (Frazin et al., 1976). A special transducer had been specifically developed for this purpose to obtain echocardiographic images in patients with chronic obstructive pulmonary disease in which transthoracic echocardiography (TTE) could not provide images of sufficient quality (Frazin et al., 1976). This transducer was particularly difficult to swallow and the method was temporarily abandoned until October 1978, when Dr. Yaso Oka proposed combining an M-Mode echocardiographic transducer with an oesophageal stethoscope (Oka, 2002). This transducer was successfully used to assess left ventricular dimensions, volumes, cardiac output and ejection fraction in a 65-year-old woman undergoing mitral valve repair (Matsumoto et al., 1979). One year later, transoesophageal echocardiography (TEE) used in intraoperative continuous monitoring of left ventricular performance was reported (Matsumoto et al., 1980).

By the late 1980s, phase-array transducers capable of two-dimensional imaging, colour and spectral Doppler had become available and this led to a widespread increase in the usage of TEE, not only in cardiac surgery but also in other areas of anaesthesiology and cardiology. In 1989, Omoto et al. (1989) introduced biplane TEE, rendering TEE examinations more versatile. Since then, significant technological advances in the field of echocardiography have been achieved and very small, high-resolution, electronic multiplane TEE transducers mounted at the tip of modified, flexible, endoscopes are now available.

The close proximity of the oesophagus to the heart and minimal intervening structures enable acquisition of high-resolution images and optimal imaging of the heart base anatomy and related structures (Loyer and Thomas, 1995). Both in human and veterinary medicine, consistently superior images of heart base structures can be obtained by TEE when compared to routine TTE (Khandheria and Oh, 1992; Loyer and Thomas, 1995). The first descriptions of the use of TEE in dogs and cats date from the 1990s (Urbanowicz et al., 1990; Bashein and Martin, 1991; Loyer and Thomas, 1995; Kienle et al., 1997).

Technique

Transducers

TEE transducers consist of a phased array ultrasound transducer mounted at the tip of a modified flexible endoscope of 70–120 cm in length (Fig. 1A). The transducer can be steered cranially or caudally within the oesophagus and rotated in a clockwise or anticlockwise direction. The guidance control allows the tip of the TEE probe (transducer) to be flexed ventrally (forward bending or anteflexion) or dorsally (backward bending or retroflexion) at least 90° and a locking mechanism allows the tip to be kept in the desired position (Fig. 1B–D).

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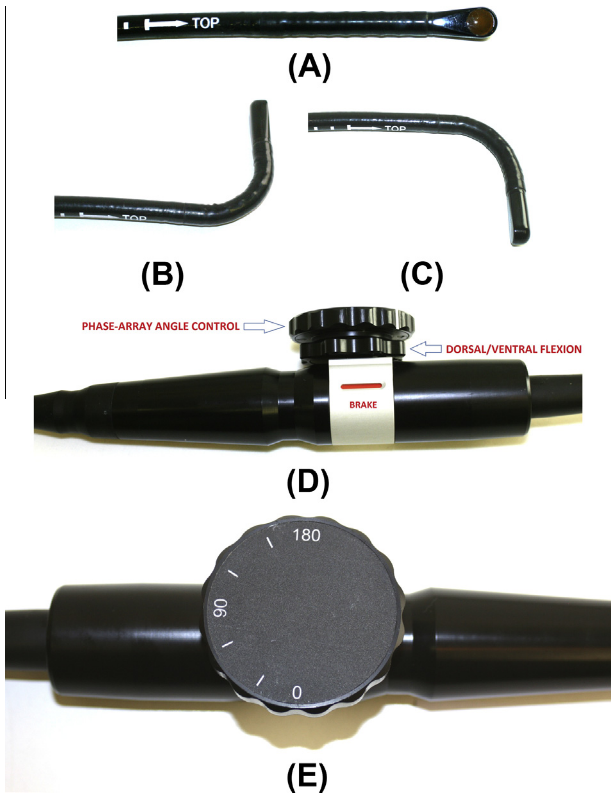

Fig. 1. (A) Transoesophageal probe; (B) retroflexion (backward bending); (C) anteflexion (forward bending); (D) control wheels and brake; (E) control wheel for transducer angle rotation.

The phased array transducer may also be rotated from 0° to 180° within the transducer tip in multiplane probes. In this way, multiple views of the heart can be produced from the same position in the oesophagus (Fig. 1E). Increasing the angle from 0° to 180° is described as forward rotation and the opposite as backward rotation. Probe dimensions vary and adult and paediatric probes are used. Larger probes for adult human patients have a shaft width of 8–11 mm, a transducer tip width of 40 mm and are 10 mm in height. Smaller paediatric probes have a shaft width that can range from 5.2 to 7.5 mm, with a transducer tip width of 7.5–10.6 mm and are 5.5–8 mm in height. In humans, although an adult probe has been successfully used in infants as small as 14.7 kg, the use of the paediatric probe is recommended in veterinary patients weighing <20 kg (Hilberath et al., 2010). In the author's experience, an adult probe could be used safely in dogs as small as 3–4 kg, but the paediatric probe should be considered in smaller dogs or cats.

Transducer frequency is also very important if images of sufficient quality are to be obtained. Ideally a transducer of at least 7.5–10 MHz should be chosen in smaller veterinary patients or to visualize heart base structures. In larger dogs, or to visualize structures that are farther away from the transducer, a lower frequency transducer (4–8 MHz) is ideal. Unfortunately, due to the cost of a TEE probe, most veterinary centres are limited to only one transducer, both in size and frequency. The authors of this review use an adult probe with a frequency range of 5–7.5 MHz (Esaote TEE022 Multiplane Probe) with a commercially available ultrasound machine (Esaote MyLab Vet30 Gold and Esaote MyLab Class C).

Examination

TEE examinations are usually performed with the animal in right lateral recumbency under general anaesthesia, although some authors have reported good results with heavy sedation (Kienle et al., 1997). Animal positioning might also vary according to the operator's preference and does not seem to limit image acquisition and quality (Loyer and Thomas, 1995). The use of a mouth guard is strongly advised to avoid damage to the transducer. Once the animal and the mouth guard are in position, the probe is gently introduced into the mouth with the transducer tip (flat side) facing down and then advanced into the oesophagus in the unlocked position. Probe manipulation must always be gentle and if resistance is encountered, force must never be used. Modifying the position of the neck might be necessary to advance the probe through the thoracic inlet in some cases.

At the level of the cranial mediastinum, resistance might again be encountered as the probe presses against the aortic arch. At this point, mild retroflexion of the transducer tip is necessary to advance further in the oesophagus and images of the heart should start appearing on the screen. TEE views are obtained from three positions in the oesophagus (cranial, middle and caudal), as well as a transgastric position (Loyer and Thomas, 1995). The order in which these views are produced can vary among operators, but it is important that a standardized method be adopted to ensure that all structures are appropriately examined.

Some authors have found it useful to start with the transgastric position to achieve proper orientation and then proceed with the examination from caudal to cranial positions. The display of TEE images usually conforms to the standards of the American Society of Echocardiography (Shanewise et al., 1999). Cranial structures are displayed to the left of the screen and caudal structures to the right of the screen (Bussadori and Domenech, 2012). This orientation differs from previous reports of biplane TEE imaging in the dog, in which cranial structures were displayed to the right of the screen and caudal structures to the left, similar to the orientation used in TTE in veterinary medicine (Loyer and Thomas, 1995). The authors find the American Society of Echocardiography standard orientation more useful since it corresponds to the animal's spatial anatomical orientation in right lateral recumbency and renders the manipulation of catheters more intuitive during interventional procedures. Finally, the sector apex corresponds to the beam origin and is displayed on top of the screen, whereas the far field is displayed on the bottom of the screen.

Cranial views

With the probe in the cranial thorax in a neutral position (not flexed) as described above, the transducer tip is retroflexed and advanced caudally until an image of the heart base is produced (Fig. 2A). Angulation of the tip towards the left might be necessary to avoid tracheal interference (Loyer and Thomas, 1995). With the array angle set at 0°, a transverse plane will be obtained with the aorta in cross-section seen on the centre of the screen, with the right ventricular (RV) outflow tract to the left and the RV inflow region to the right (Fig. 2B). Slight forward angle rotation is necessary to optimize this view. By slightly advancing the probe, both the ascending and descending sections of the aorta can be seen with the pulmonic valve on the left, the main pulmonary trunk and right pulmonary artery on the near field and the RV outflow tract on the far field (Fig. 2C; Video 1). Slight clockwise rotation might be necessary to optimize this view. By further advancing the probe, both pulmonary artery branches and the main pulmonary trunk can be examined (Fig. 2D). The cranial transverse views allow optimal morphological studies of the RV outflow tract, pulmonic valve and main pulmonary artery, as well as Doppler interrogation of flow in these areas. From this position, rotating the transducer anticlockwise allows visualization of the left atrial appendage in some dogs (Fig. 2E).

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