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***Technical Note***

# Ultrasound Probe with Integrated ECG Lead: Feasibility Study

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We integrated electrocardiogram (ECG) leads onto the face of a cardiac ultrasound transducer and the exterior chassis of a simulated small, portable scanner to minimize the number of devices needed to collect cardiac information. Since the ECG leads were not placed on their standard locations, a precordial ECG was recorded.

Key words: ECG; electrocardiogram; ultrasound probe.

## I. INTRODUCTION

There is a trend toward smaller, more portable ultrasound scanners. While Terason (Echo t3000, Burlington, MA), GE (LOGIQ Book XP, Milwaukee, WI) and Sonosite (Micromaxx, Bothell, WA) all have portable devices the size of a laptop computer, prototype devices the size of a Personal Digital Assistant (PDA) have also been described.[1] A goal of these miniature devices is to mimic the feel of a stethoscope which can hang around the neck of the physician Thus, it would be cumbersome to have a full set of ECG leads dangling from the small, hand-held scanner.

A complete ECG consists of nine leads, which produce a total of 12 separate signals. Six of these signals are formed by the placement of six precordial leads on the chest wall.[2] Commercial cardiac ultrasound scanners often incorporate a set of three ECG leads including the right arm (RA), right leg (RL), and left arm (LA) electrodes. The significant features of an ECG are the P, Q, R, S and T waves. The P wave is the result of atrial depolarization, the QRS complex is due to ventricular depolarization and ventricular repolarization produces the T wave.[2] Thus, in order for an ECG to be correctly interpreted by a physician, it should contain these major features.

In this paper, we consider a design wherein one of three ECG leads is integrated onto the face of the transducer of the ultrasound scanner while the other two leads would be integrated into the chassis of a hand-held scanner, ideally the size of a PDA (Fig. 1).

## II. PROCEDURE

We used the Volumetrics, Inc. Model V360 (Durham, NC) real-time 3D ultrasound imaging system to obtain our ultrasound images. This system also includes a three-lead ECG de-



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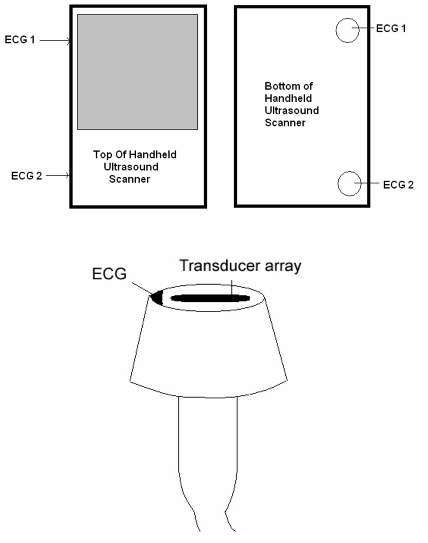


**FIG. 1** Proposed ultrasound and ECG device.

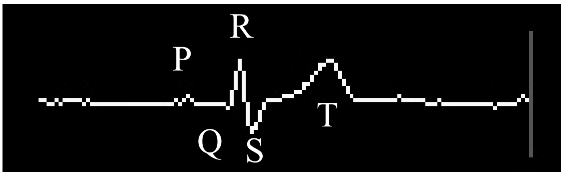


**FIG. 2** Control ECG.

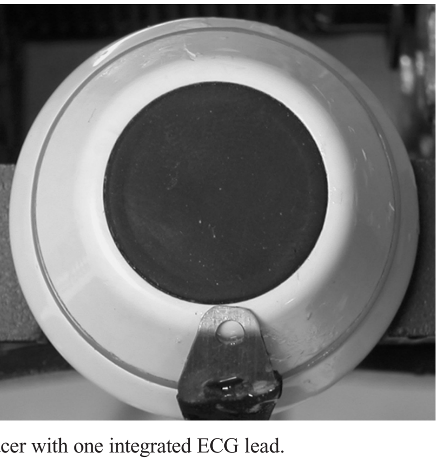

**FIG. 3** Ultrasound transducer with one integrated ECG lead.

tector. We obtained a conventional ECG by placing the leads on the right arm, the left arm and the left leg of a normal subject. This ECG was used as our control (Fig. 2).

In our new design, a single ECG electrode was bonded to the transducer face to produce a precordial lead (Fig. 3). Two other electrodes were bonded to the bottom of a laptop computer to simulate the attachment of these electrodes to the chassis of a portable ultrasound scanner. When the laptop was placed on the right side of the subject's chest, the adhesive ECG electrodes were connected to the subjects torso.

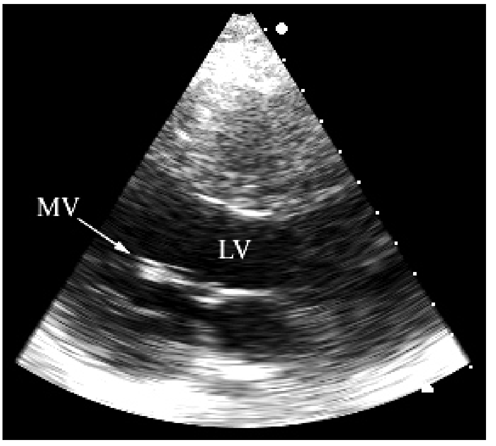


**FIG. 4** B-scan ultrasound image The image shows an oblique long axis view of the heart with the left ventricle (LV) and mitral valve (MV).

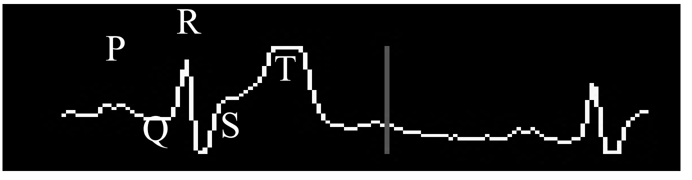


**FIG. 5** ECG obtained with one ECG lead attached to the face of the transducer. Two other leads were attached to the right chest wall.

We imaged the heart (Fig. 4) and produced a simultaneous ECG (Fig. 5) in good agreement with the control.

## III. DISCUSSION

We tested the feasibility of a design of a portable ultrasound-ECG device with one ECG lead attached to the transducer face with two ECG electrodes integrated into the scanner chassis on three subjects. In each case, we were able to produce successful results. Comparing the control ECG (Fig. 2) with the experimental ECG (Fig. 5), we see good similarity between the two. The two signals are from the same volunteer. We see the P wave, QRS complex and T wave in both signals. We note amplifier saturation in the T wave in the experimental.

The placement of the ECG leads is important. We also placed all three leads on the transducer but no signal was recorded. This may have been due to the limited distance of the three vectors central to the recording of an electric signal in the heart. However, we were able to obtain an ECG reading when two leads were attached to the transducer, though the ECG was unconventional. Lead placement on the transducer and the location of the transducer while imaging will also affect the observed ECG signal as various acoustic windows represent different precordial lead locations.

In addition to integrating ECG leads into the transducer face, a small microphone could also be incorporated into the transducer to obtain a phonocardiogram. Also, the leads on the base of the handheld device could be made to extend away from the device and retract back into it to add flexibility for patients with irregular body shapes and to guarantee adequate separation of the leads.

## REFERENCES

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