Comparing Ejection Fraction Measurements Generated Using Conventional and Robot-Assisted Echocardiography Scanning

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INTRODUCTION

Medical robotics is an emerging field in healthcare with applications to surgery and drug production. Although medical robotics is applied to solve a range of problems in healthcare, its use for assisting in diagnostic imaging is still in its early stages. In this study, we evaluate the use of a robotic arm for echocardiography or ultrasound imaging of the heart, which is widely used for scanning cardiac patients. Despite its widespread use, the modality requires prolonged scanning, which can cause fatigue and variability in image quality [1,2]. Robot-assisted ultrasound systems offer automated transducer control, potentially reducing scan time and operator strain while maintaining consistent imaging. In this study, we compare left ventricular ejection fraction (LVEF) measurements obtained using conventional manual echocardiography with those acquired through the proposed robot-assisted system.

MATERIALS AND METHODS

The proposed robot-assisted echocardiography system [3] consists of a UR10e robotic arm (Universal Robots, Odense, Denmark) and an X5-1 transducer connected to a Philips EPIQ 7C ultrasound scanner (Philips Healthcare, Eindhoven, The Netherlands). A custom 3D printed mount was used to attach the X5-1 transducer to the end effector of the robotic arm. The robot-arm was controlled semi-automatically using a laptop computer via an Ethernet cable connected to the robotic arm. This Study was approved by the Human Research Ethics Board at the University of Alberta. Informed consent was obtained from all 29 patient participants, who had undergone a routine echocardiography examination within 24 hours prior to the robot-assisted session.

RESULTS AND DISCUSSION

The EFs and scan durations are reported in Table 1. The mean (± standard deviation) EF measured using the conventional clinical standard echocardiography were 41.1 ± 11.1 %, while the robot-assisted system produced 40.6 ± 9.0 %. Statistical analysis showed no significant difference between the two methods (paired t-test, $p = 0.789$), indicating that the robot is capable of producing EF values comparable to manual scans. These results suggest that robotic assistance maintains diagnostic accuracy. Fig. 1 shows a Bland–Altman plot comparing EF measurements from robot-assisted and conventional scans. Robot-assisted scanning reduced the overall scanning duration. The mean clinical scan time was 33.3 ± 12.8 min, compared with 23.3 ± 5.0 min for robot-assisted scans (paired t-test, $p < 0.001$).

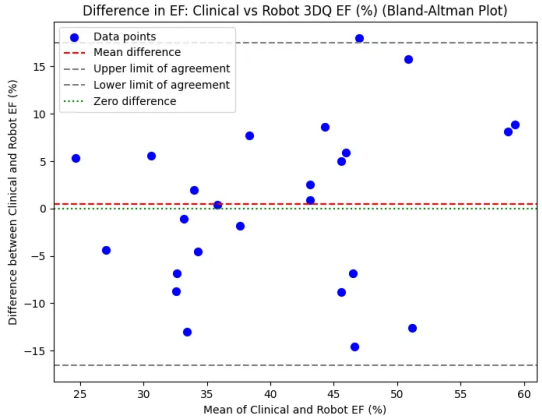

Fig. 1 Bland-Altman Plot Showing the Difference Between Clinical and Robot Scan EF Result.

CONCLUSIONS

This study highlights the potential of robot-assisted echocardiography to enhance clinical efficiency without compromising diagnostic quality. Our initial investigations with patient participants show that the robot-assisted system reduces the scanning time while maintaining the diagnostic image quality. Future work will focus on optimizing autonomous scan protocols to further reduce the scanning time.

REFERENCES

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Table 1: Comparison of EF and Scan Duration Data Between Clinical and Robot Scans.

	Clinical Scans	Robot Scans	*p-value*
Ejection Fraction EF (%)	41.11 ± 11.15	40.65 ± 8.98	$p = 0.789$
Scan Duration (minutes)	33.31 ± 12.80	23.31 ± 5.02	$p = 0.0001$