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## Training/Practice
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# Avoiding Clinical Errors With Bedside Echocardiography: A Randomized Clinical Study

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**ABSTRACT**

**Clinicians have strong opinions about whether they should be provided the clinical history before or after bedside testing. We hypothesized that diagnostic accuracy is improved when a concordant clinical history is provided before a diagnostic test. To investigate whether the timing (before or after) and the consistency (concordant vs discordant) of the clinical history in the setting of focused bedside echocardiography affects clinician diagnostic accuracy and management decisions. Thirty-two cardiology residents were asked to perform a bedside echocardiogram on a Vimedix 3D mannequin. Half of the histories were provided before echocardiography and half after echocardiography. Half were consistent with the echocardiographic diagnosis (concordant), and half were suggestive of a plausible alternative diagnosis (discordant). Participants were asked for a diagnosis and management plan. The primary outcome was the diagnostic accuracy of the echocardiographic images. The secondary outcome was the management plan. Overall diagnostic accuracy was 63%. If the clinical**

**RÉSUMÉ**

**Les cliniciens ont des opinions très tranchées quant à savoir s'ils devraient prendre connaissance des antécédents cliniques avant ou après les examens au chevet du patient. Notre hypothèse était que l'exactitude du diagnostic est améliorée lorsqu'un dossier clinique concordant est transmis avant un test diagnostique. Pour déterminer si le moment (avant ou après) de la communication du dossier clinique et sa cohérence (dossier concordant ou discordant) dans le contexte d'une échocardiographie ciblée au chevet du patient ont une influence sur l'exactitude du diagnostic posé par le clinicien et sur ses décisions de prise en charge, trente-deux résidents en cardiologie ont été invités à effectuer une échocardiographie au chevet d'un mannequin Vimedix 3D. La moitié des dossiers leur ont été communiqués avant l'échocardiographie et l'autre moitié après cet examen. La moitié des dossiers étaient compatibles avec le diagnostic échocardiographique (antécédents concordants), tandis que l'autre moitié des dossiers évoquaient la possibilité d'un autre diagnostic plausible (antécédents**

Diagnostic errors are costly and prevalent, affecting up to 1 in 20 individuals in the United States.[1] Whether the clinical history should be known before diagnostic test interpretation has been heavily debated.[2] The largest available systematic analysis found that clinical context improved test reading accuracy, prompting clinicians to continue the common practice of reading diagnostic tests with clinical information.[2] However, there are several reports of decreased diagnostic accuracy when the clinical context is provided, particularly when the context is discordant or suggestive of an alternative diagnosis.[2] Previous studies suggest that the effect may be moderated by expertise, type of subspecialist, consistency of clinical information with the ultimate diagnosis, and complexity of the task and diagnosis.[3]

In this study, we hypothesized that diagnostic accuracy may be improved if a concordant clinical history is provided before echocardiographic testing, measuring both diagnostic and management decision accuracy.

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history was provided before the bedside testing, it significantly improved diagnostic accuracy if it was concordant and it diminished accuracy if it was discordant (odds ratio [OR], 0.35; 95% confidence interval [CI], 0.16-0.80; $P = 0.001$). Clinical history, whether concordant or discordant, had no significant impact if provided after the images were obtained. Appropriate management was chosen 77% of the time and was chosen less often with discordant compared with concordant histories (OR, 0.25; 95% CI, 0.11-0.57; $P = 0.001$). Our study suggests a significant downside to clinical information received before echocardiography when the information is discordant, raising the possibility that receiving clinical information after echocardiography may be superior for diagnostic accuracy.

discordants). Les participants étaient invités à poser un diagnostic et à établir un plan de traitement. Le critère d'évaluation principal était l'exactitude diagnostique des images échocardiographiques. Le critère d'évaluation secondaire était le plan de traitement. L'exactitude diagnostique globale a été de 63 %. La communication des antécédents cliniques avant l'examen a eu pour effet d'améliorer de manière significative l'exactitude diagnostique si ceux-ci étaient concordants et de diminuer cette exactitude s'ils étaient discordants (rapport des cotes [RC], 0,35; intervalle de confiance [IC] à 95 %, de 0,16 à 0,80; $p = 0,001$). Les antécédents cliniques, concordants ou discordants, n'ont eu aucune incidence significative s'ils étaient communiqués après l'obtention des images. Le plan de traitement approprié a été choisi dans 77 % des cas, et ce choix approprié a été fait avec une fréquence moins élevée dans le cas d'antécédents discordants que dans celui d'antécédents concordants (RC, 0,25; IC à 95 %, de 0,11 à 0,57; $p = 0,001$). Les résultats de notre étude semblent indiquer que la communication des données cliniques avant l'échocardiographie présente des risques importants lorsque les données sont discordantes, ce qui soulève la possibilité qu'une telle communication après l'échocardiographie soit plus avantageuse pour assurer l'exactitude du diagnostic.

## Methods

### Participants

Thirty-two of 33 eligible cardiology residents from the University of Toronto were included. Of the participants, 13 were in their first year of cardiology training, 11 were in their second year, and 8 were in their final year. The average number of months of echocardiography training varied from $1 \pm 0.2$ months for those in their fourth postgraduate year to $5 \pm 0.4$ months for those in their sixth postgraduate year. Participants received a $10 gift card for their participation. The study was approved by the Ethics Review Committee of the University of Toronto. All participants provided informed consent.

### Design

Participants were asked to perform a bedside echocardiogram on a high-fidelity Vimedix cardiology simulator (CAE Healthcare, Saint-Laurent, Qubec) capable of reproducing echocardiographic images in the parasternal, apical, and subcostal views. Participants were told that the study assessed how clinical history impacted their diagnostic process; they were unaware that the histories could suggest an alternative diagnosis. For half of the cases, the clinical history was disclosed before the participants obtained images, whereas the other half of participants obtained images before receiving the clinical history. For cases in which clinical information was not provided beforehand, participants were asked to perform an echocardiogram and document their findings; they were then provided with clinical information before formulating a diagnosis and management plan. Because of time constraints, participants were allotted 4 minutes for each echocardiogram. A target sample size of 98 was calculated based on extrapolation from previous studies looking at the effect of concordant histories in cardiac physical examination.

### Intervention

Participants received 4 emergency scenarios (Supplemental Appendix S1). Computer-generated $2 \times 2$ block randomization ensured that each condition was tested in each scenario in equal proportions. The 4 clinical scenarios (normal, cardiac tamponade, acute myocardial infarction, and aortic dissection) are common reasons for a bedside echocardiogram requiring echocardiography-based management decisions. Residents were asked to follow a computer template that took them through questions related to each scenario (Supplemental Appendix S2). For each scenario, 2 experts (Y.M. and M.S.) constructed 2 histories: 1 that suggested the diagnosis (concordant history) and 1 that suggested a plausible alternative diagnosis (discordant history). Data were collected in the simulation laboratory affiliated with the University of Toronto. Participants and those assessing outcomes were blinded to allocation.

### Data analysis

The primary outcome was the accuracy of the echocardiographic diagnosis. Two experts (Y.M. and M.S.), blinded to the study conditions, independently scored the data set and resolved discrepancies through discussion. The diagnoses were evaluated as correct or incorrect and scored as 1 or 0, respectively. All synonyms and compatible diagnoses were scored as correct, as long as they were more consistent with the echocardiographic diagnosis than the suggested alternative in the discordant history.

Management plans were independently scored as either an "appropriate" or "less appropriate" management plan based on the consensus management of 2 experts (Y.M. and M.S.). For example, in the case of cardiac tamponade, participants who recommended pericardiocentesis received scores of "appropriate management plan," whereas participants who recommended further monitoring or computed tomography received scores of "less appropriate management plan." Agreement was uniform with no discrepancies. Management plans were also categorized based on their invasiveness, regardless of whether they were appropriate or less appropriate: (1) institute therapy, (2) investigate further, and (3) monitor.