# A bedside ultrasound technique for fluid therapy monitoring in severe hypovolemia: Tissue Doppler imaging of the right ventricle

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**Abstract:** Fluid therapy is one of the main issues for hemodynamic resuscitation. Tissue Doppler imaging (TDI) of the right ventricle (RV) with bedside ultrasound (BUS) technique is a new dynamic method to identify fluid responsiveness in patients with hypotension. Here, we present the case of a hypotensive patient monitored with TDI measurements of RV. A 75-year-old male patient was admitted to the emergency department (ED) with the complaint of diarrhea. He was in severe hypovolemia, with hypotension, tachycardia, and tachypnea. His laboratory results were normal. BUS was performed on the patient by the ED physician. The velocity of the excursion of the tricuspid valve measured at presentation was 14.47 cm/s and, together with collapsed inferior vena cava (IVC), this finding led to the decision to begin fluid therapy immediately. The patient underwent 2 L of fluid therapy with 0.9% NaCl in a 2-h period. Control BUS after fluid therapy revealed decreased TDI velocity of tricuspid annulus to 11.81 cm/s and dilated IVC not collapsing sufficiently with respiration. The patient received his maintenance therapy after admission to the internal medicine department and was discharged from the service after 3 days. TDI in fluid responsiveness may find a clinical role in the future by the clinical studies.

**Keywords:** bedside ultrasound, emergency medicine, fluid therapy, right ventricle, tissue Doppler imaging

## Introduction

Fluid therapy is one of the main issues for hemodynamic resuscitation. Fluids are administered to increase cardiac output, and, ultimately, tissue perfusion. However, the physician should identify the patient in the rising part of the Frank–Starling curve, not in the plateau phase, in order to see a positive response to fluid therapy. The recognition of patients in the rising part of this curve can be provided by some non-invasive measurements with bedside ultrasound (BUS) technique, such as velocity-time integral (VTI), changes in peak aortic velocity and inferior vena cava (IVC) diameter with respiration. Tissue Doppler imaging (TDI) of the right ventricle (RV) with BUS is a new dynamic method to identify fluid responsiveness in patients with hypotension. Here, we present the case of a hypotensive patient monitored with TDI measurements of the RV.

## Case Report

A 75-year-old male patient was admitted to the emergency department (ED) with the complaint of vomiting and diarrhea. He was in severe hypovolemia, with hypotension (75/43 mmHg), tachycardia (130/min), and tachypnea (26/min). On physical examination, there were cold extremities, delayed capillary refill time, and sweating. A 12-lead ECG showed sinus tachycardia, but arterial blood gas analysis revealed no specific abnormality. His laboratory results were normal, except for the increased blood leukocyte count, and blood urea nitrogen to creatinine ratio. BUS was performed by the ED physician using a Terason model ultrasound machine with a 3.6 MHz micro-convex transducer (uSmart 3200T, Boston, MA, USA) and views of the apical 4-chamber view at the apex of the heart and subcostal view of the IVC revealed increased TDI velocity of the RV from the lateral annulus of the tricuspid valve and slit-like IVC under the left lobe of the liver *(Fig. 1)*. The velocity of the excursion of the tricuspid valve measured at presentation was 14.47 cm/s and, together with collapsed IVC, this finding led to the decision to begin fluid therapy immediately. Written informed consent form was obtained from the patient prior to participation in the study.

The patient underwent 2 L of fluid therapy with 0.9% NaCl in a 2-h period. Control BUS after fluid therapy revealed decreased TDI velocity of tricuspid annulus to 11.81 cm/s and dilated IVC not collapsing sufficiently with respiration *(Fig. 2)*. Also, the blood pressure and other findings were normalized. The patient received his maintenance therapy after admission to the internal medicine department and was discharged from the service after 3 days.

## Discussion

Although the evidence is not strong enough, there is a significant experience with the use of BUS to predict the fluid responsiveness in critically ill patients [1]. Most commonly, ED physicians prefer to use BUS since the procedure is non-invasive and, moreover, physical examination findings, hematocrit levels, and biochemical markers are not specific indicators [2]. VTI is one of the BUS measurements that have been shown to be highly predictive of fluid responsiveness if respirophasic changes of VTI are greater than 20% [3]. The other method for

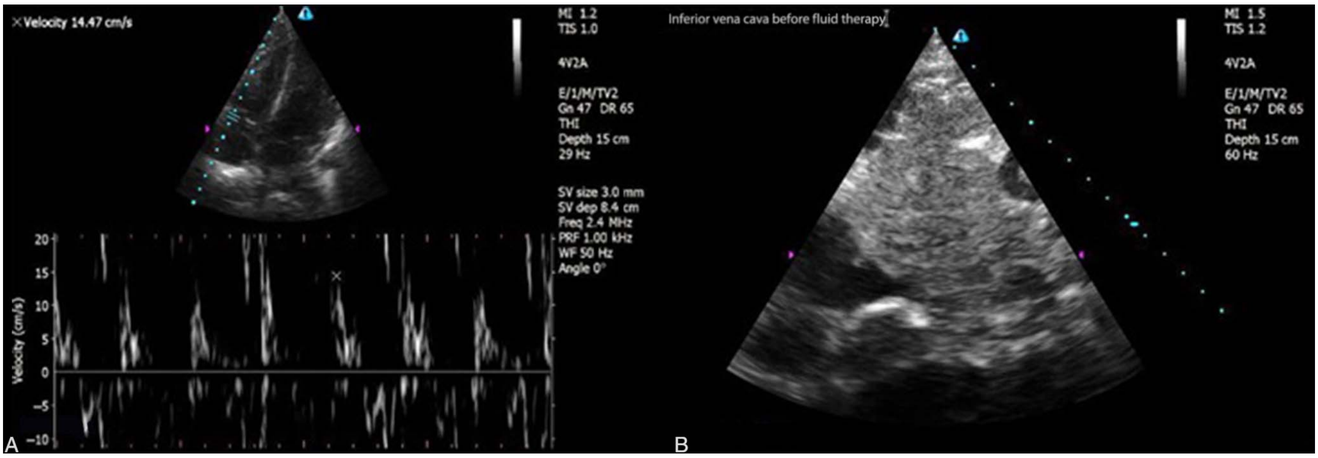


**Fig. 1.** (A) Bedside ultrasound (BUS) performed by the emergency department (ED) physician revealed increased TDI velocity of the right ventricle from the lateral annulus of the tricuspid valve. (B) BUS performed by the ED physician revealed a slit-like inferior vena cava under the left lobe of the liver

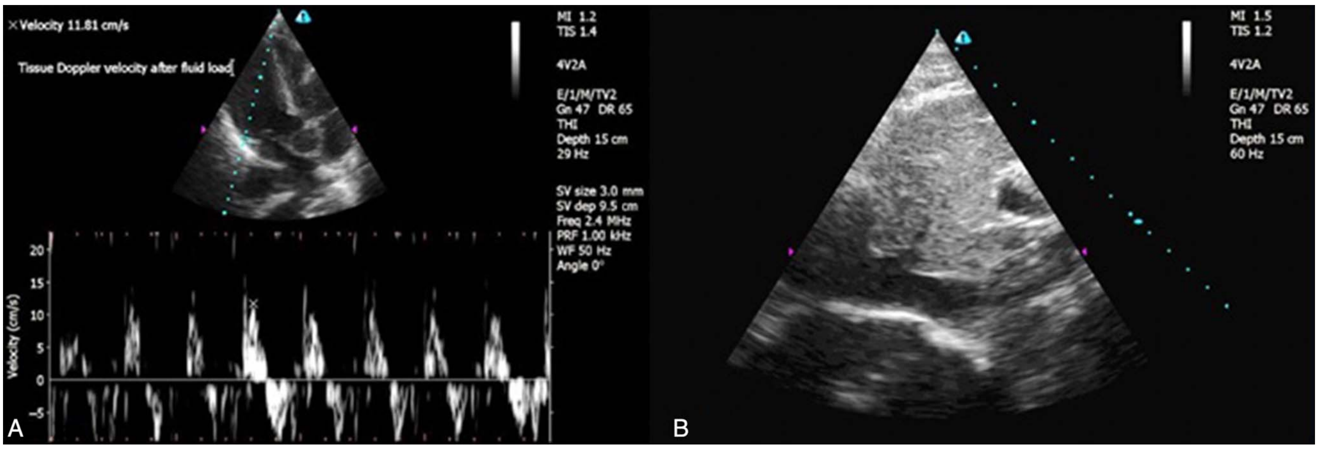


**Fig. 2.** (A) Control bedside ultrasound (BUS) after fluid therapy revealed decreased TDI velocity of the right ventricle from the lateral annulus of the tricuspid valve. (B) Control BUS after fluid therapy revealed that the inferior vena cava is dilated and not collapsing sufficiently with respiration

predicting fluid response is identification of the respiratory-induced changes in peak aortic velocity [3]. This same study showed that left ventricular end-diastolic area, as a proxy of preload, did not discriminate between responders and non-responders; this finding was confirmed in a meta-analysis [4]. In some studies, it has been shown that increasing respirophasic changes in the diameter of IVC during positive pressure breathing, detect fluid-responsive patients. These changes in diameter of the IVC can effectively identify fluid responsiveness in septic patients, with a suggested cutoff point of 12% of the mean diameter [5, 6]. In contrast to these dynamic measurements of fluid responsiveness with BUS, static ones, such as IVC diameter, were not found to be clinically useful. In addition, these methods do not depict the response of the RV to fluid challenge directly. We have shown that TDI identifies RV function and pulmonary resistance directly. TDI is superior to blood flow Doppler as it directly reflects myocardial function and is less subject to loading conditions. Low values of systolic (Sm), diastolic early (Em), and diastolic late (Am) tissue velocities of the right RV have been proposed to reflect systolic and diastolic RV dysfunction, respectively [7]. Only a limited number of researchers have investigated the diagnostic accuracy of TDI on right ventricular dysfunction in different clinical settings. In mechanically ventilated patients, TDI velocities have been shown to successfully discriminate patients with different durations of weaning [8]. In a recent study of Harmankaya et al. [9], RV-Sm was found lower in the non-surviving septic shock patients compared with the surviving and the control groups (11.8 ± 4.2, 13.6 ± 3.3, and 15.1 ± 2.1 cm, respectively, $P = 0.002$).

## Conclusions

With the increased availability of portable ultrasound devices with the TDI feature in EDs, monitoring applications with RV tissue Doppler in fluid responsiveness may find a clinical role, particularly if it is demonstrated to be superior to the available alternatives in future strong studies.

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