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CASE REPORT

Emergency department right atrial pressure and intravascular volume estimation using right ventricular tissue Doppler bedside ultrasonography

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Abstract A 41 year old woman with a history of colon cancer metastatic to her lung and liver, presented to the emergency department severely dehydrated. Bedside ultrasonography revealed a tumor mass in her proximal inferior vena cava at the junction of the right atrium obstructing the ability to assess her volume status with inferior vena cava inspiratory collapse. Bedside emergency department cardiac tissue Doppler ultrasonography of the lateral right ventricle and pulse Doppler ultrasonography of the tricuspid valve was used to estimate her right atrial pressure and intravascular volume status.

Keywords Ultrasound · Tissue Doppler imaging · Right atrial pressure estimation · Volume depletion · Metastatic colon cancer

Case report

A 41-year-old woman with a past medical history of colon cancer metastatic to her lung and liver and a history of multiple rounds of failed chemotherapy, presented to the emergency department from home with a 2-week history of nausea and vomiting and decreased appetite and oral intake, weakness, mild shortness of breath on exertion and chronic abdominal pain. Her ED vital signs were temperature 98.7, heart rate 124, blood pressure 96/50, respiratory rate 22, room air oxygen saturation 100%, and her ECG showed sinus tachycardia. Her physical examination revealed an alert woman with a tachycardic heart rate, she had dry oral mucosa, her lungs were clear, she had moderate right side abdominal tenderness on palpation, and her legs had no edema and there was no popliteal tenderness. A portable chest X-ray revealed a normal heart size, no effusions and multiple lung nodules. Laboratory studies included a BUN of 14 mg/dl (normal 7–20 mg/dl) and creatinine 0.6 mg/dl (normal 0.5–0.9 mg/dl) and a BUN/creatinine ratio of 23.

An ED bedside ultrasound was performed of the abdomen and heart (see Video Clips S1, S2, S3 and S4 available as supporting information in the online version of this paper) and revealed an enlarged liver with diffuse metastatic tumor masses (Fig. 1) and a hyperdynamic heart (Video Clip S2). The inferior vena cava was collapsed in the subcostal short axis view (Fig. 2). The inferior vena cava contained a tumor mass at the junction of the right atrium in the subcostal long axis view (Fig. 3). In addition, in the apical four chamber view, pulsed wave Doppler evaluation of the tricuspid valve (at the coaptation point of the tricuspid leaflet tips) revealed a 38.2 cm/s velocity early diastolic E wave (Fig. 4). Tissue Doppler evaluation of the lateral basal right ventricle wall with a 5-mm sample volume revealed a 14.6 cm/s velocity early diastolic E_a wave (Fig. 5).

The patient was given 2 l of intravenous normal saline in the emergency department and her vital signs normalized with a repeat blood pressure of 116/72 and heart rate of 80. Her lungs remained clear after rehydration. She was admitted to the oncology service for continued hydration and palliation therapy.

Electronic supplementary material The online version of this article (doi:10.1007/s13089-010-0030-7) contains supplementary material, which is available to authorized users.

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Fig. 1 Liver with metastatic tumor masses

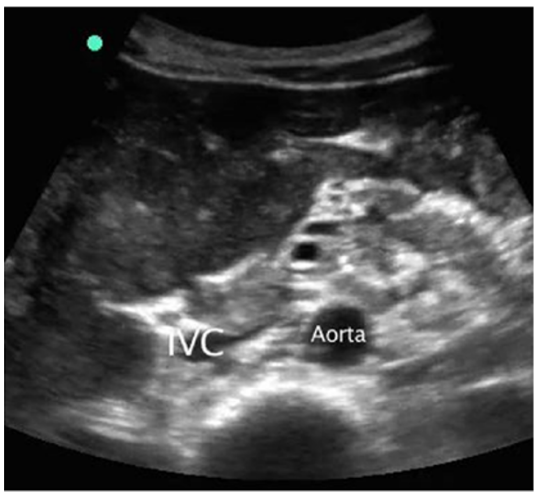

Fig. 2 Inferior vena cava collapsed short axis view

Discussion

Ultrasound evaluation of the inferior vena cava can assist the clinician in estimating right atrial pressure and volume status [1–3]. A 50% inspiratory collapse of a normal-sized inferior vena cava in the subcostal IVC long axis view measured within 2 cm of the right atrial junction has been used to estimate the right atrial pressure at 10 mmHg, which is consistent with a normal intravascular volume state or a full tank [1–3]. Patients who are volume depleted will often have an IVC <1.2 cm with >50% inspiratory collapse of the IVC [1]. A volume depleted patient can be resuscitated with intravenous fluids, the tank can be refilled, and this usually occurs when the right atrial pressure has reached 10 mmHg [1–3]. Interestingly, right atrial

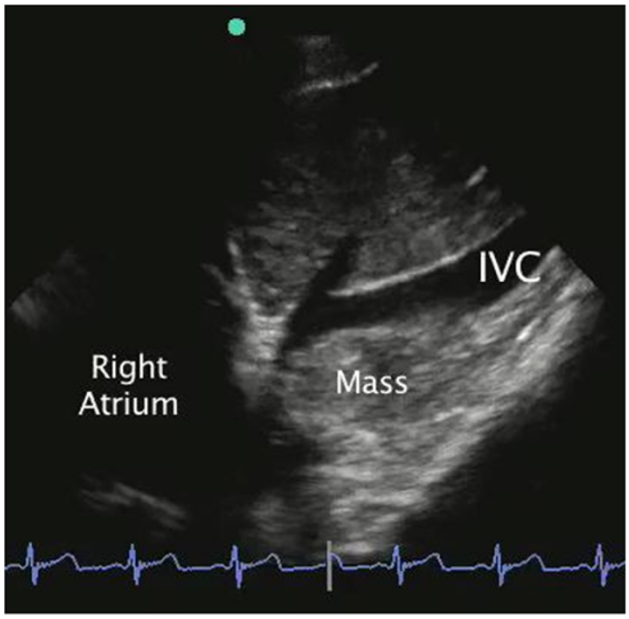

Fig. 3 Tumor mass inside the inferior vena cava

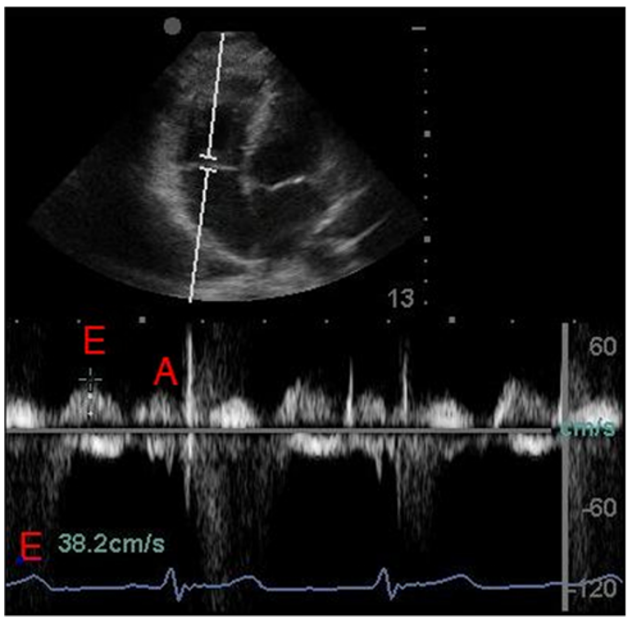

Fig. 4 Apical 4 chamber view: tricuspid pulse doppler early diastolic E wave

pressure can also be estimated by evaluating the ratio of right ventricle tricuspid diastolic *E* wave peak pulse Doppler velocity and the lateral wall right ventricle wall tissue Doppler diastolic E_a wave peak velocity [4, 5]. This method of estimating right atrial pressure is especially valuable in patients in whom the proximal IVC cannot be visualized either due to body habitus, or due to mass or tumor in the proximal IVC as was the case in our patient.

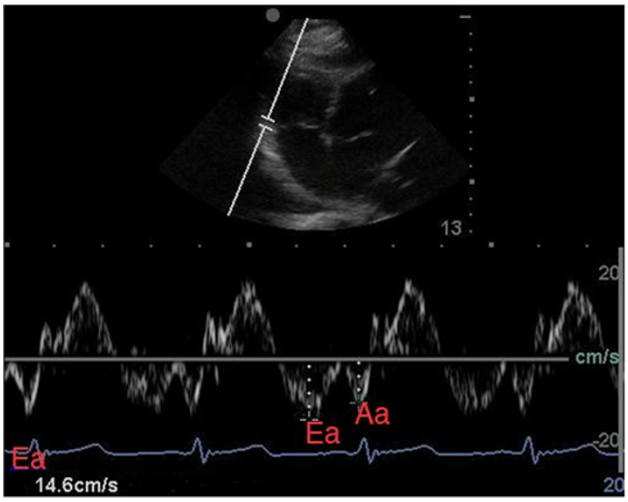

Fig. 5 Apical 4 chamber view: tissue doppler early diastolic Ea wave-lateral right ventricle

Nageh et al. [5] described in patients undergoing cardiac catheterization with direct right atrial pressure measurement, overall an E (tricuspid)/E_a (RV lateral wall) ratio >6 had a sensitivity of 79% and a specificity of 73% for mean right atrial pressure of ≥10 mmHg.

$$E/E_a > 6 : \text{RAP} \geq 10$$

where E early diastolic tricuspid pulse doppler velocity in cm/s, E_a early diastolic lateral RV tissue Doppler velocity in cm/s.

Our clinically dehydrated patient had a tricuspid pulse Doppler E wave diastolic velocity of 38.2 cm/s and a RV lateral wall tissue Doppler E_a wave diastolic velocity of 14.6 cm/s, and a E/E_a (38.2/14.6) ratio of 2.6, <6 and consistent with a right atrial pressure less than 10 mmHg and an intravascular volume depleted patient. The figures and supplemental video clips illustrate how bedside cardiac tissue Doppler ultrasonography can assist the emergency and critical care physician in the estimation of right atrial pressure and volume status especially in a patient with a proximal IVC that is difficult to visualize.

Conclusion

Bedside cardiac tissue Doppler ultrasonography of the lateral right ventricle and pulse Doppler ultrasonography of the tricuspid valve can assist the emergency and critical care physician in the estimation of right atrial pressure and intravascular volume status.

Conflict of interest None.

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