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11·1·21 - 11·4·21

Rola-Haycock

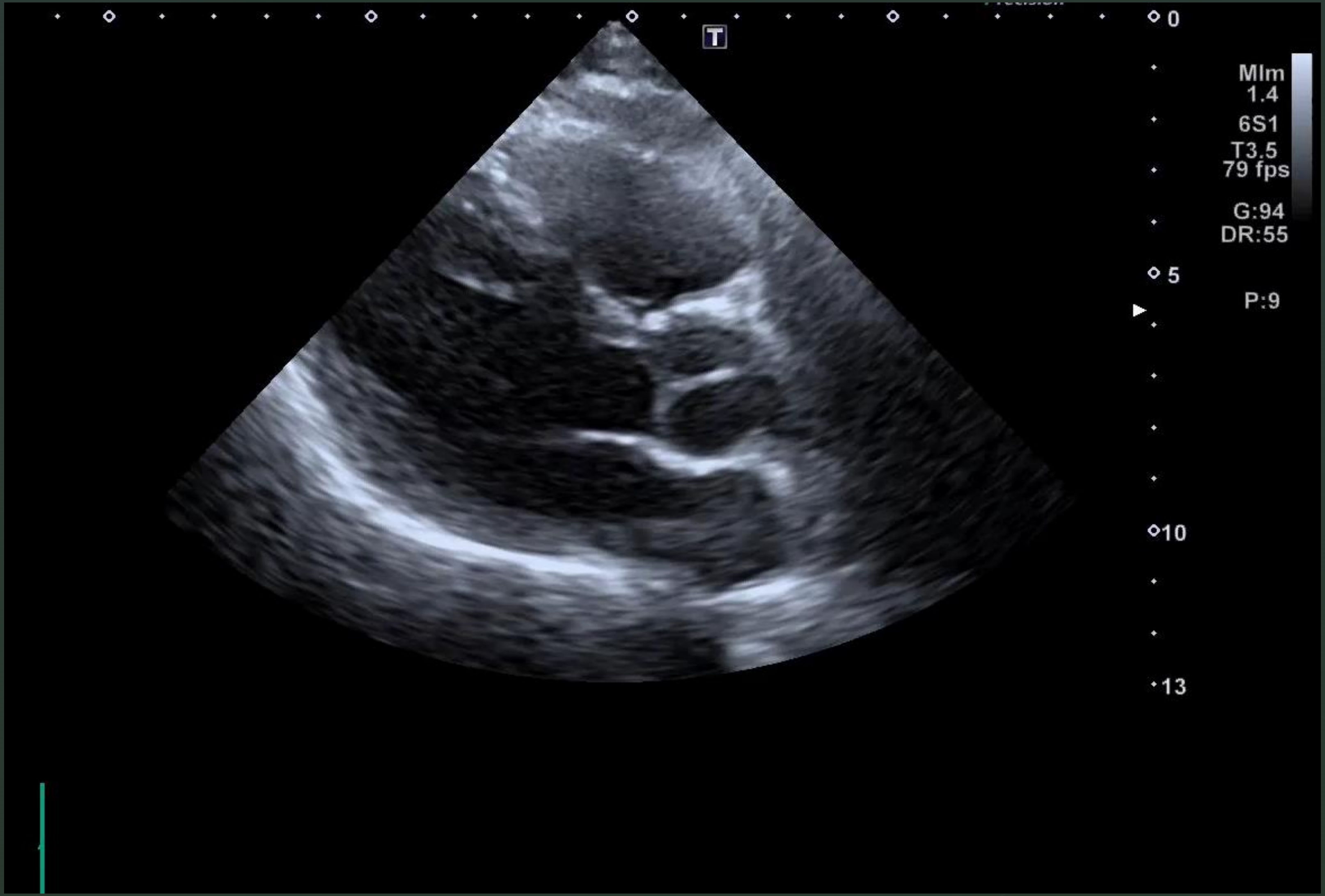
Using Echocardiography to Predict Volume Responsiveness

@ThinkingCC
@khaycock2

Conflict of Interest?

None

Measuring the Diameter of the LVOT



Measuring the Diameter of the LVOT

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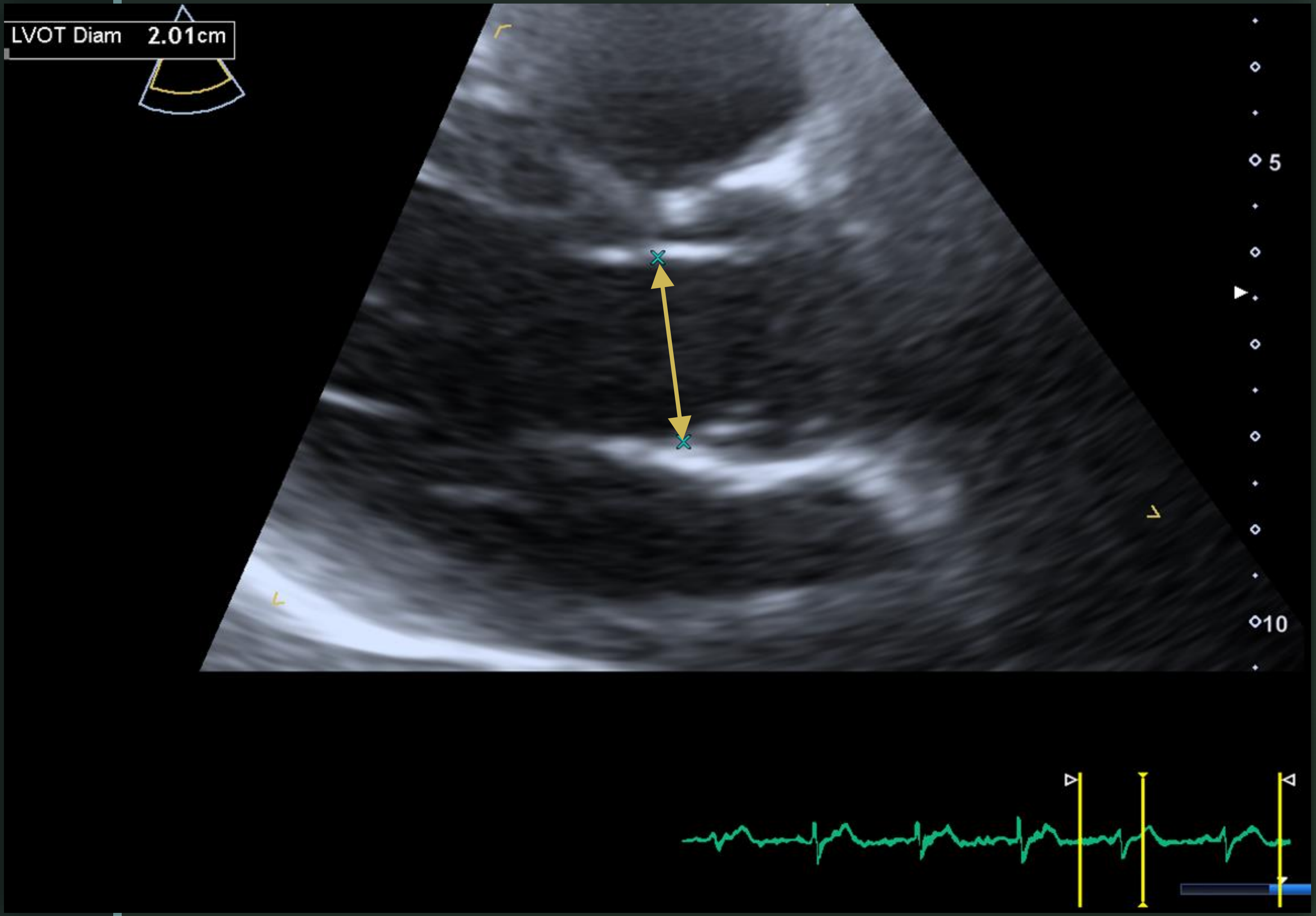


- Measure close to the insertion of the aortic valve cusps
  - Inner edge to inner edge
- Measure when the valve is completely open
- Zoom into the ROI to decrease error
  - (error will be squared for this measurement)

MEASURING THE DIAMETER OF THE LVOT

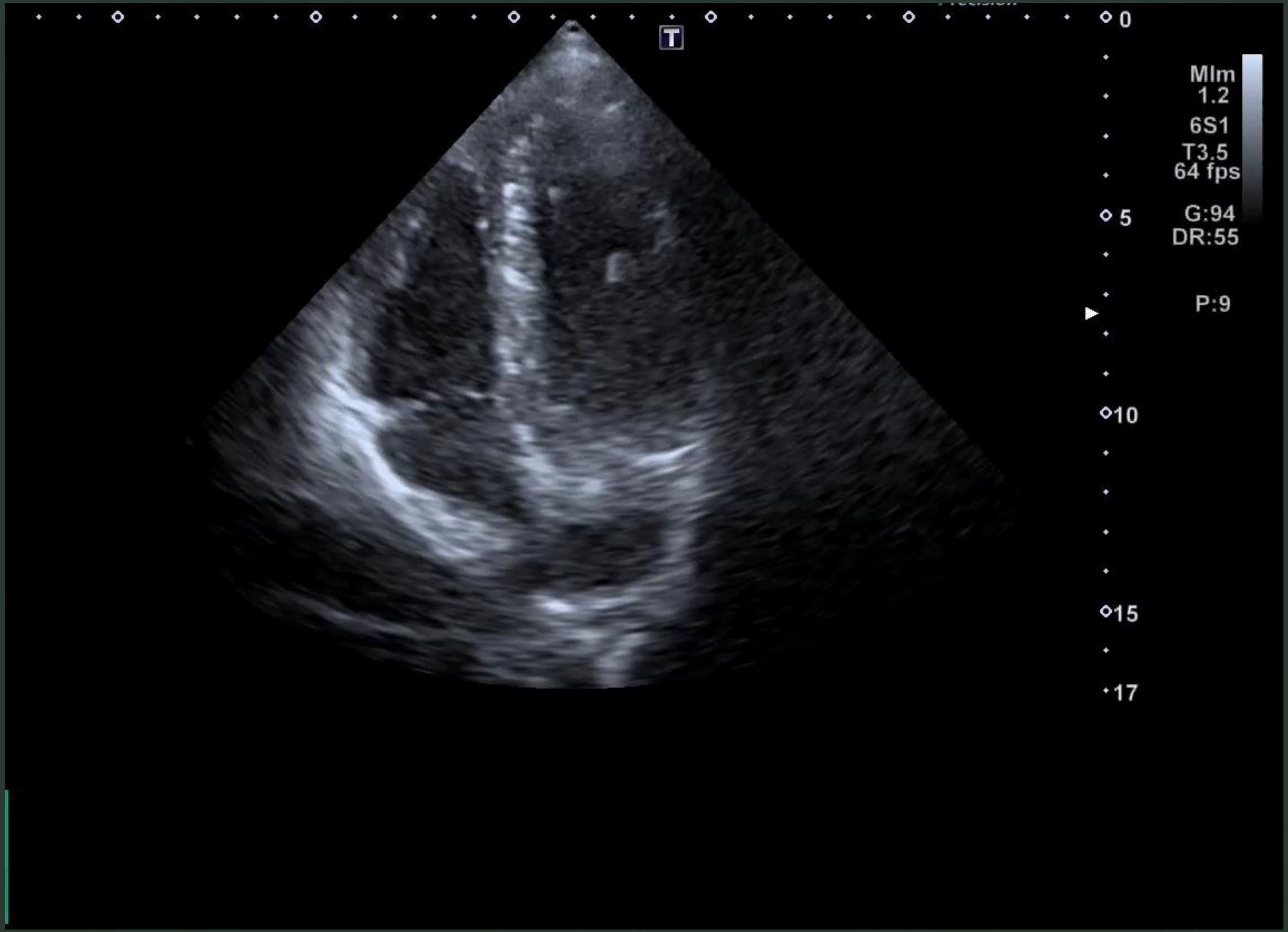
- The LVOT is nearly round
  - This size doesn't change with volume status
    - This will be useful when determining volume responsiveness
- If we can measure the diameter of a circle, we can know its area

$$\text{Area} = \pi\,(\text{radius})^2$$

or

$$\text{Area} = 0.785\,(\text{diameter}^2)$$

Measuring the LVOT VTI



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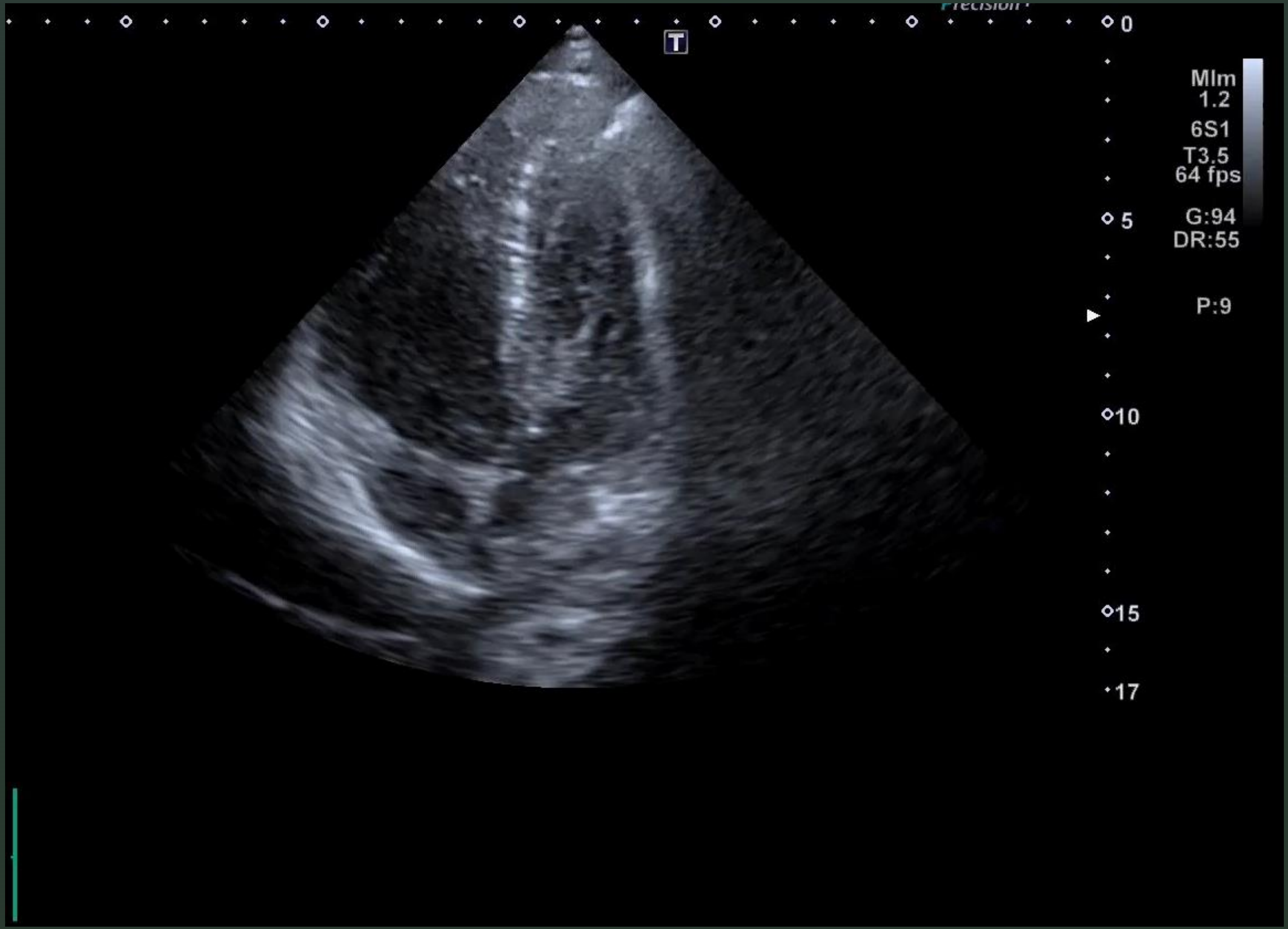

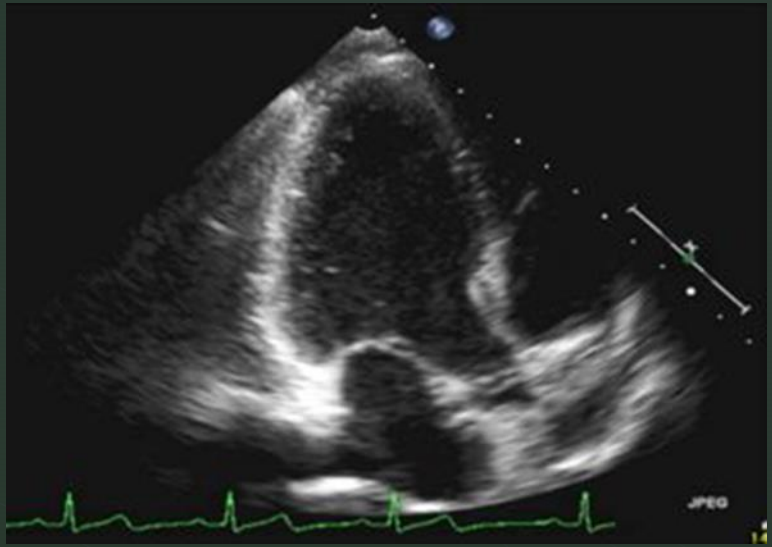

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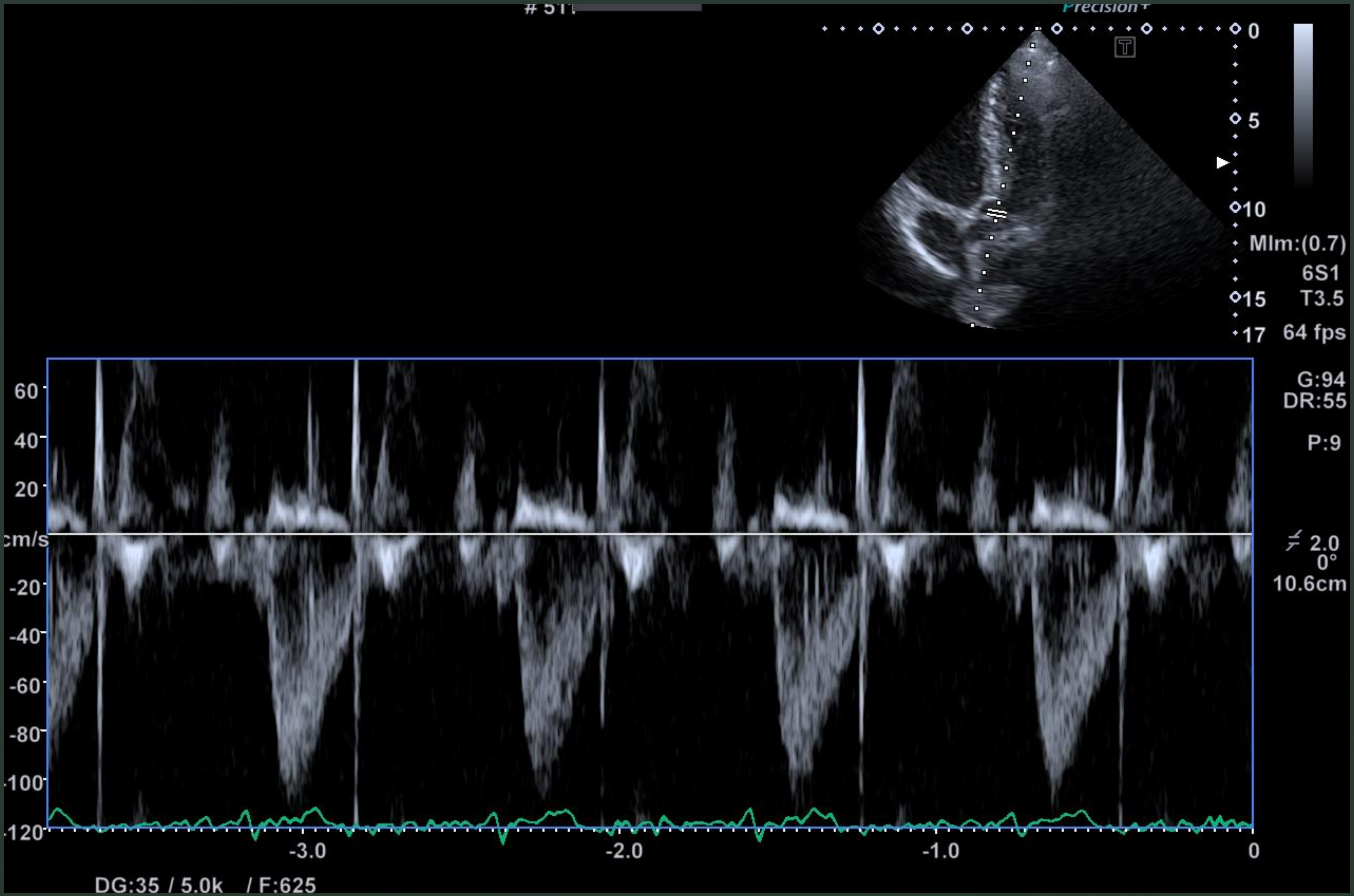

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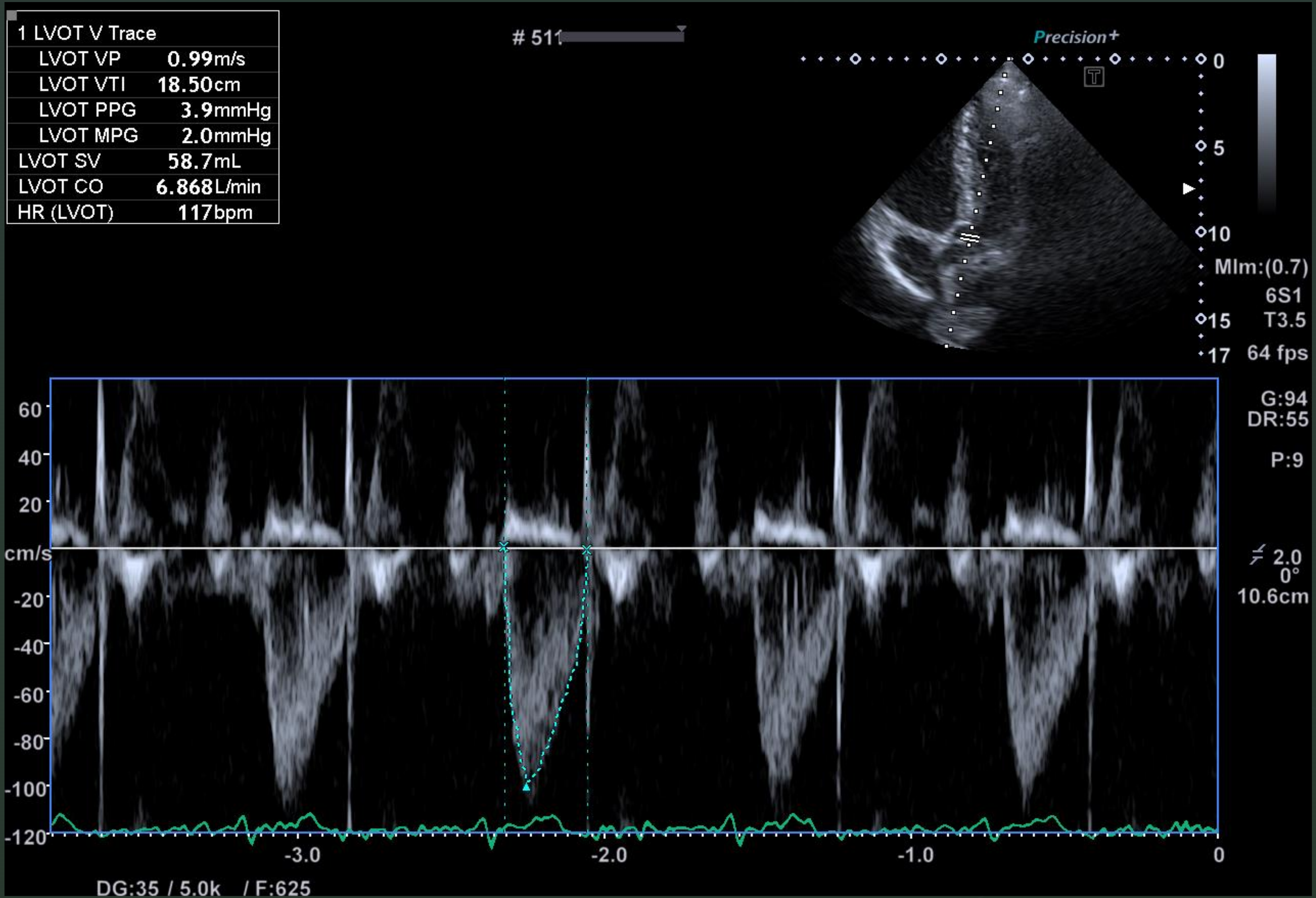
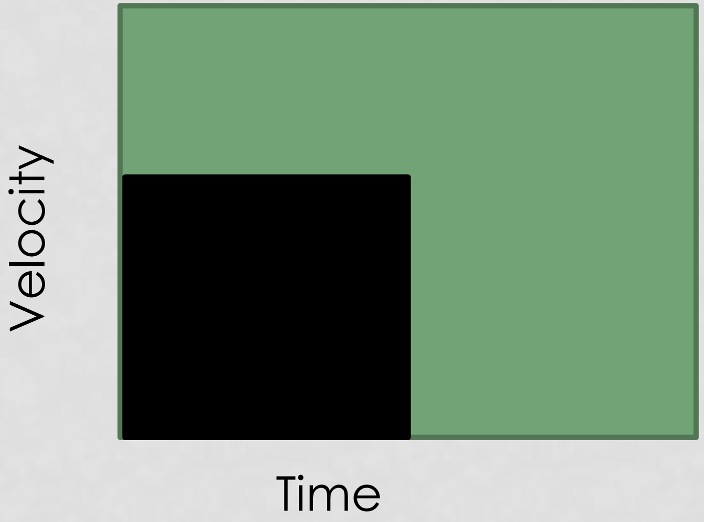
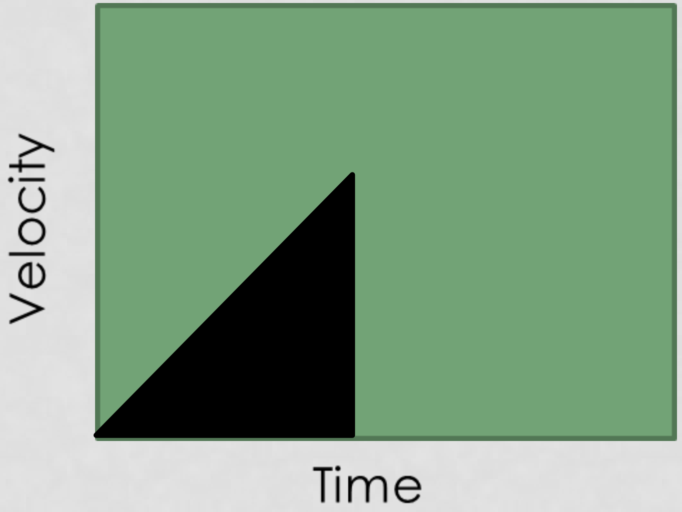
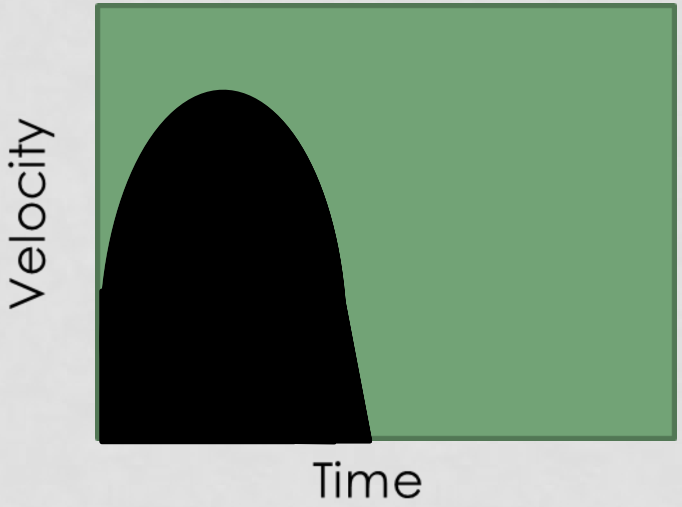


VELOCITY TIME INTEGRAL





Velocity x Time = Distance



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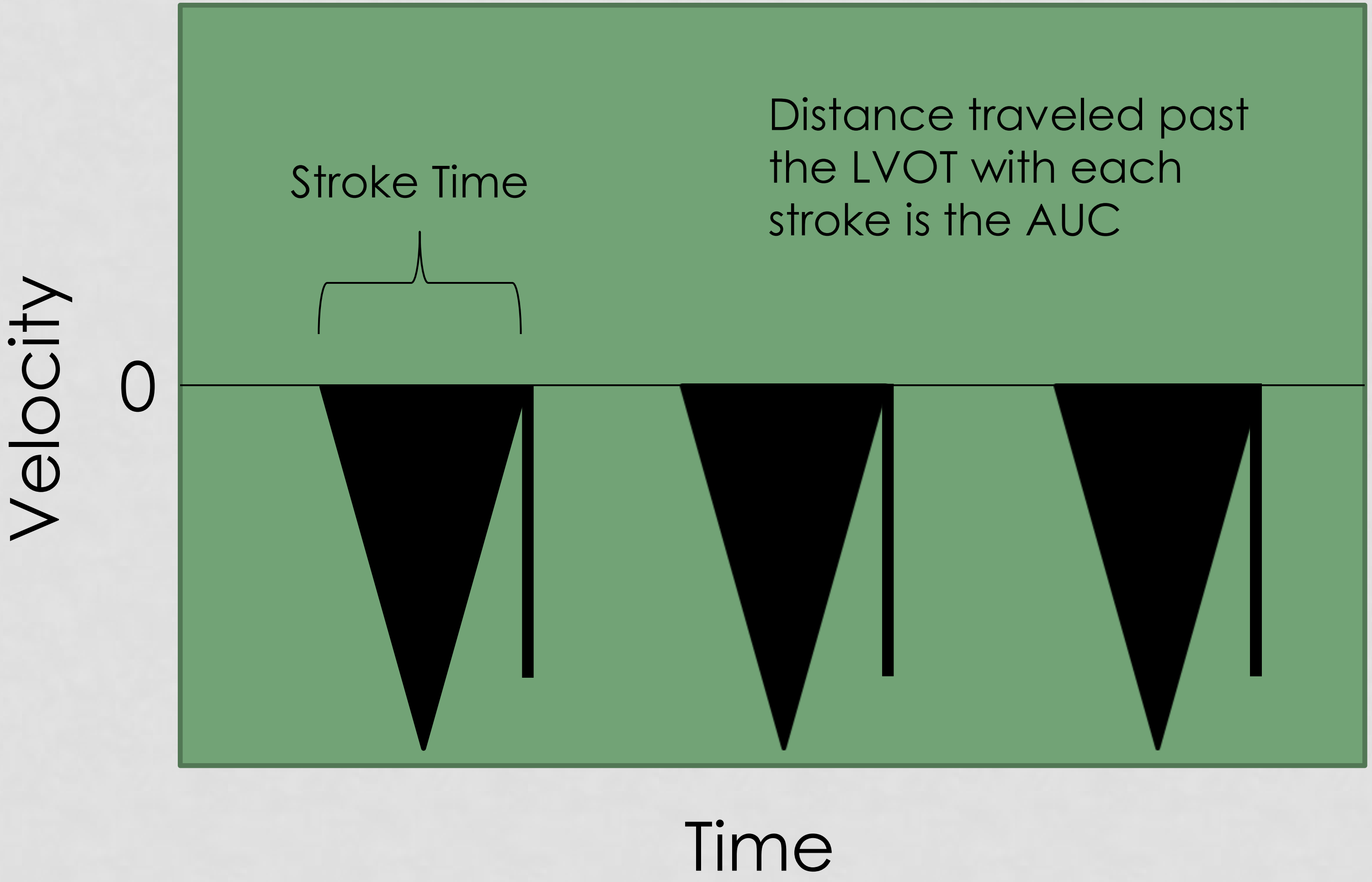
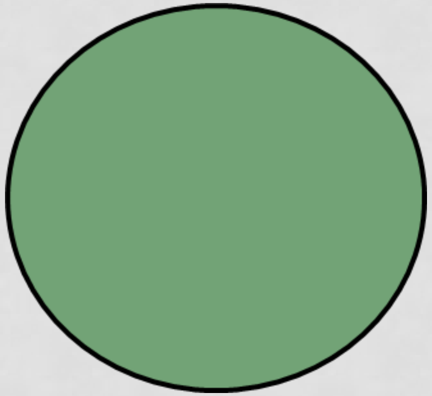


STROKE VOLUME

Area of the LVOT



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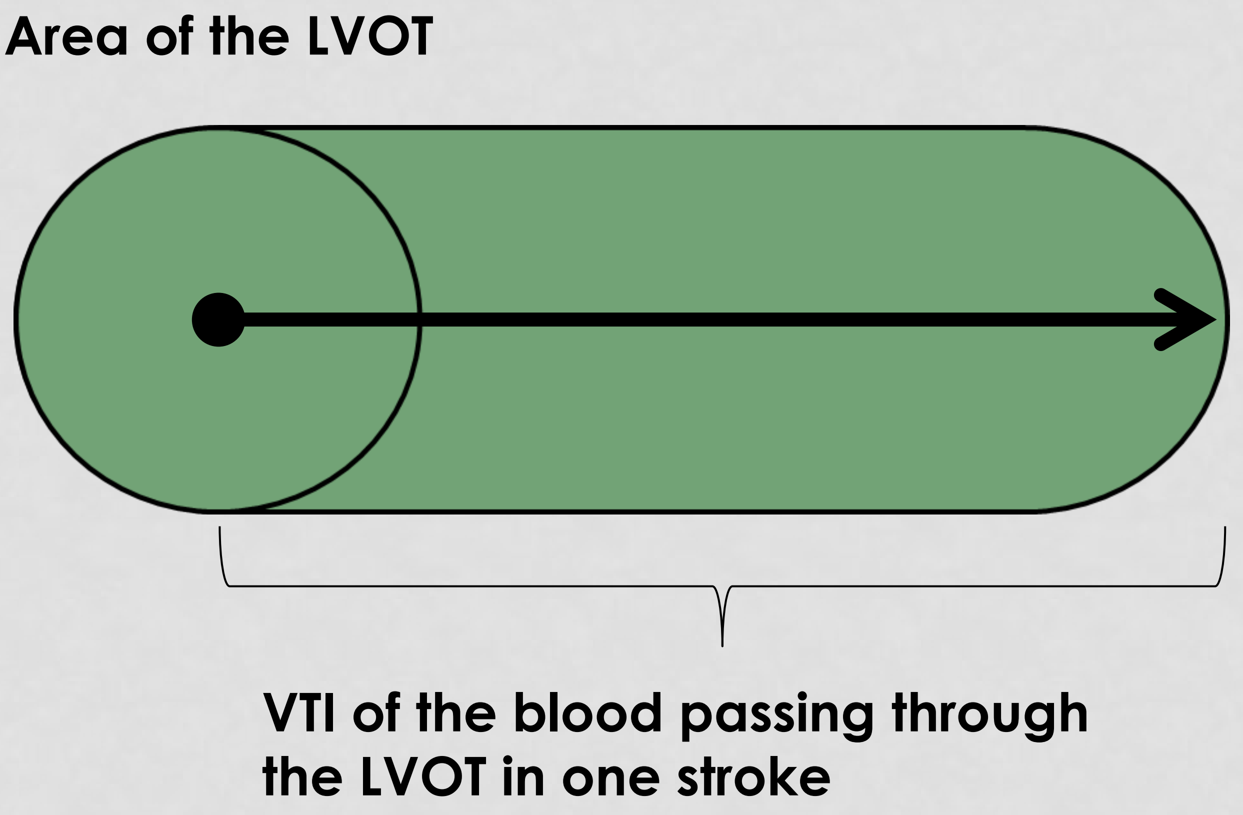
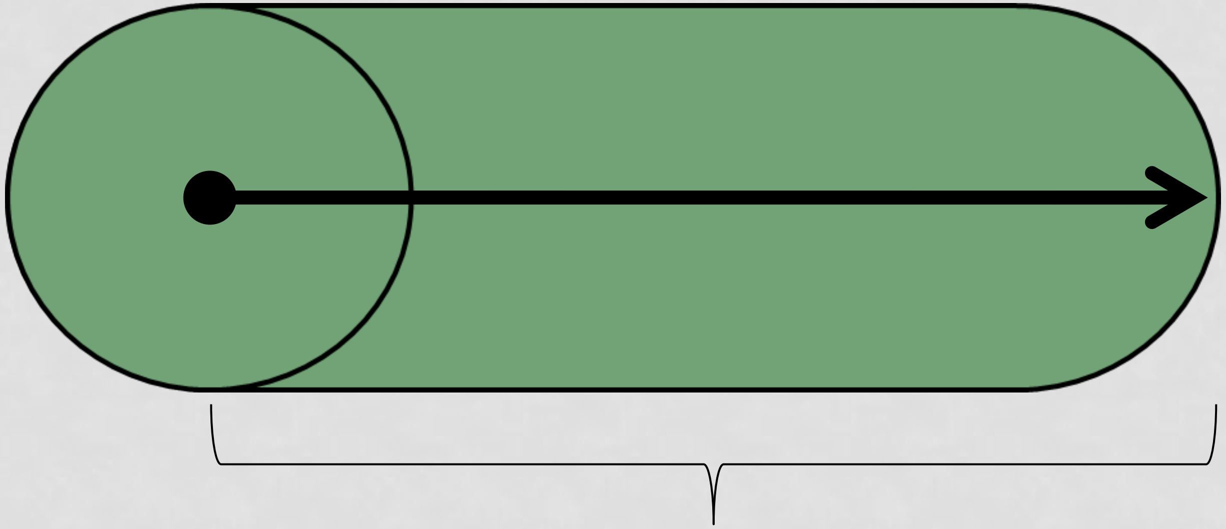


STROKE VOLUME

Area of the LVOT

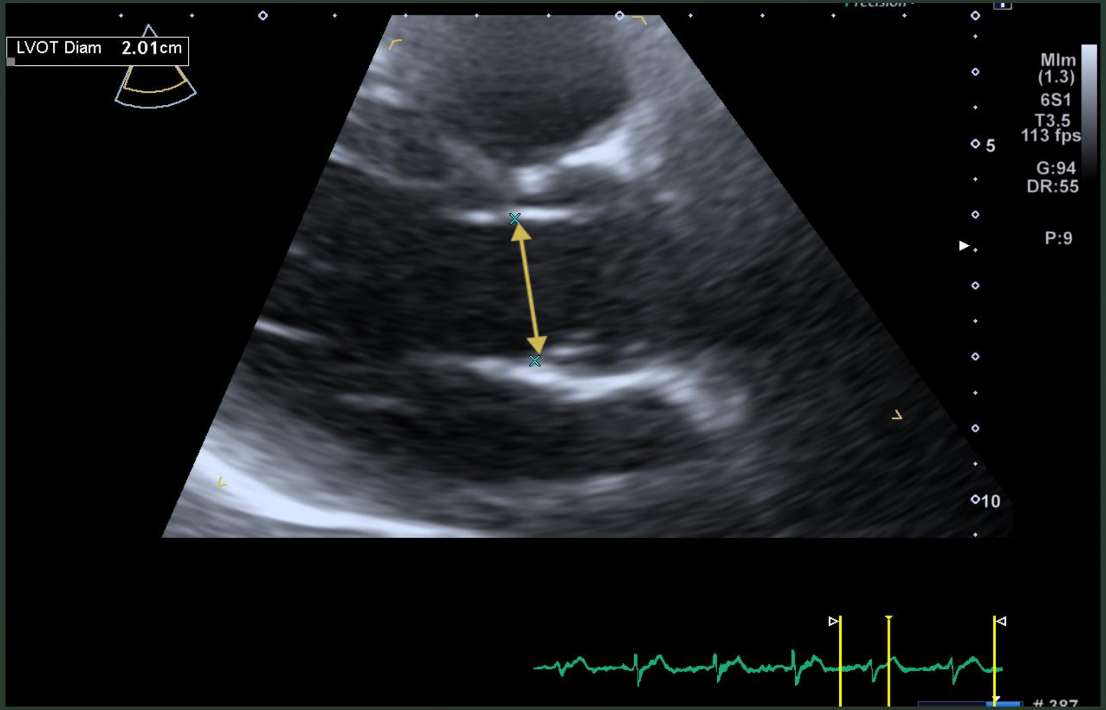


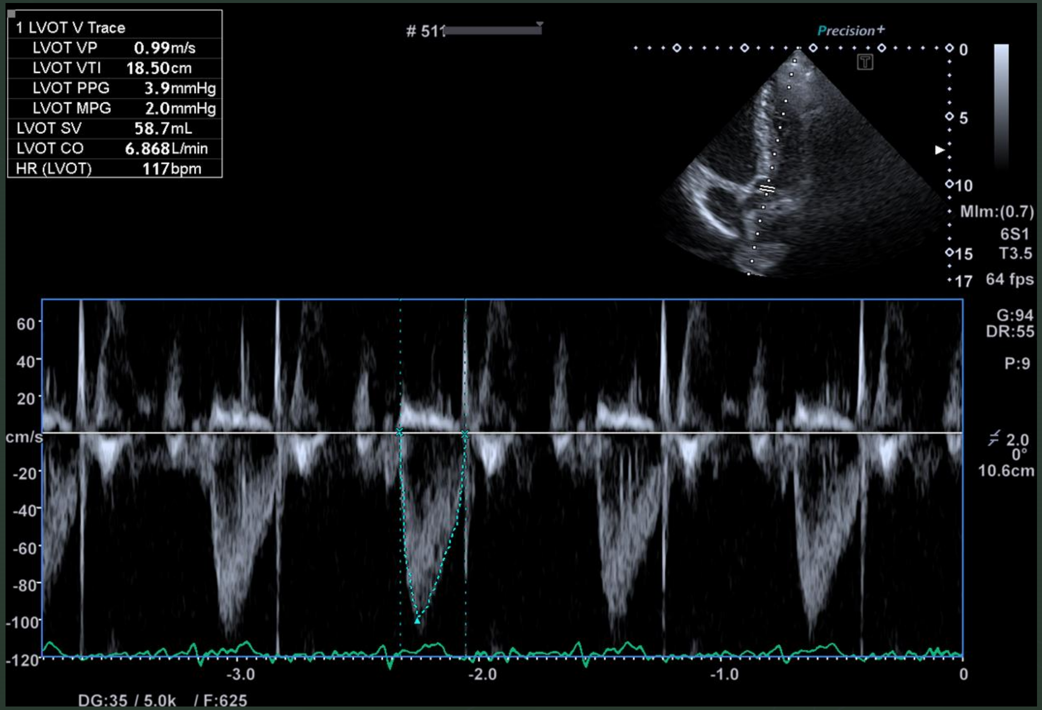
VTI of the blood passing through the LVOT in one stroke

Area x length = volume

Cardiac Output Calculation

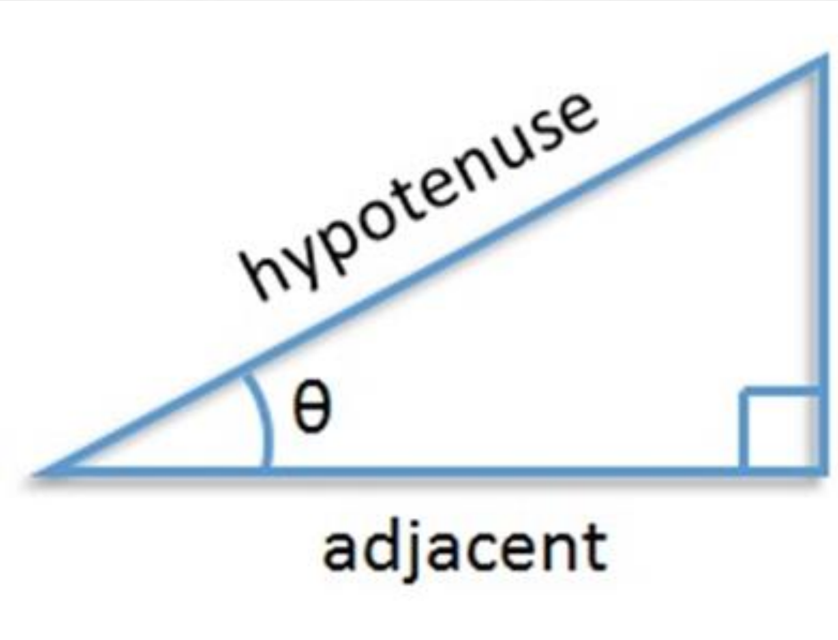
- Diameter of the LVOT squared x 0.785 x LVOT VTI = SV
- Stroke Volume x Heart Rate = Cardiac Output





SOURCES OF MEASUREMENT ERROR

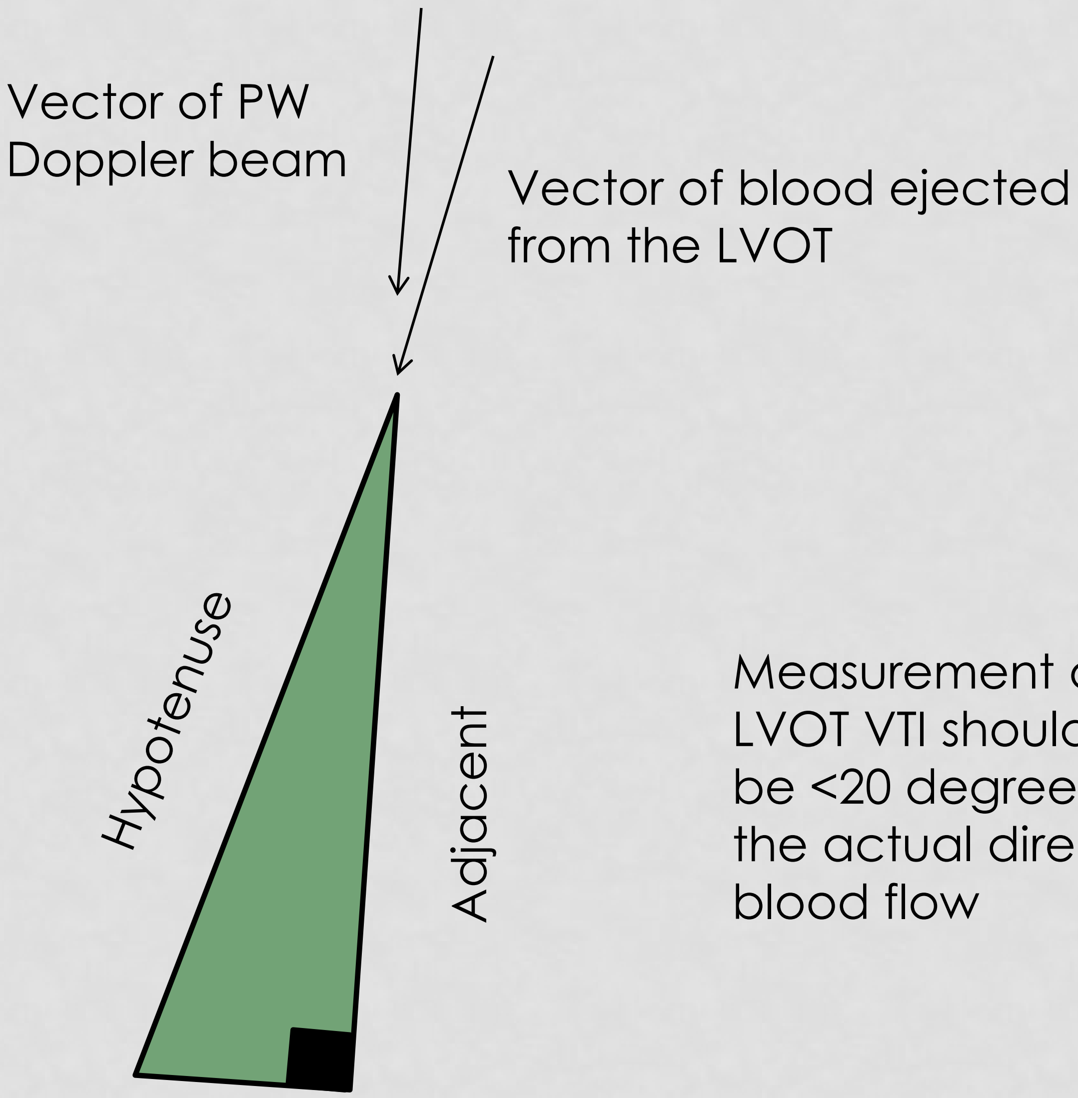
- Inaccurate measurement of the LVOT Diameter
  - Because this measurement will be squared, the error will be squared
    - Zoom into your region of interest
    - Fan through the LVOT to get the largest size
    - Measure perpendicular to the walls of the LVOT
    - Measure when the aortic valve cusps are completely open
  - Inaccurate measurement may over or underestimate flow
- Poor Doppler angles in relation to the flow of blood through the LVOT
  - Will only result in underestimation of flow
- Measuring too far into the aortic valve
  - Will overestimate flow



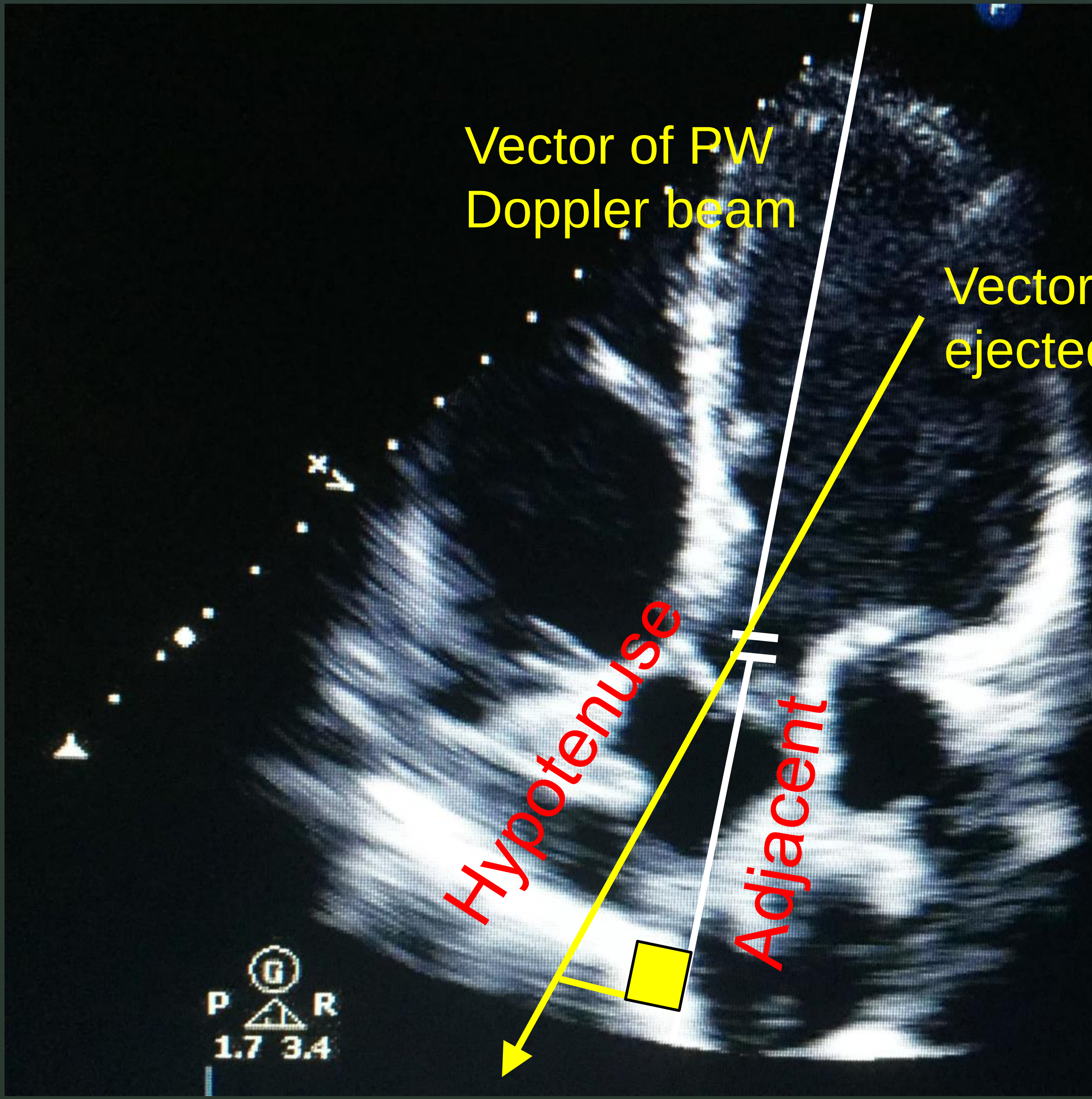
20 degrees difference = about 6% error

Table of cos(angle)

Angle	cos(a)	Angle	cos(a)	Angle	cos(a)	Angle	cos(a)
0.0	1.00	25.0	.9063	46.0	.6947	71.0	.3256
1.0	.9998	26.0	.8988	47.0	.6820	72.0	.3090
2.0	.9994	27.0	.8910	48.0	.6691	73.0	.2924
3.0	.9986	28.0	.8829	49.0	.6561	74.0	.2756
4.0	.9976	29.0	.8746	50.0	.6428	75.0	.2588
5.0	.9962	30.0	.8660	51.0	.6293	76.0	.2419
6.0	.9945	31.0	.8571	52.0	.6157	77.0	.2249
7.0	.9926	32.0	.8480	53.0	.6018	78.0	.2079
8.0	.9903	33.0	.8387	54.0	.5878	79.0	.1908
9.0	.9877	34.0	.8290	55.0	.5736	80.0	.1736
10.0	.9848	35.0	.8191	56.0	.5592	81.0	.1564
11.0	.9816	36.0	.8090	57.0	.5446	82.0	.1392
12.0	.9781	37.0	.7986	58.0	.5299	83.0	.1219
13.0	.9744	38.0	.7880	59.0	.5150	84.0	.1045
14.0	.9703	39.0	.7772	60.0	.5000	85.0	.0872
15.0	.9659	40.0	.7660	61.0	.4848	86.0	.0698
16.0	.9613	41.0	.7547	62.0	.4695	87.0	.0523
17.0	.9563	42.0	.7431	63.0	.4540	88.0	.0349
18.0	.9511	43.0	.7314	64.0	.4384	89.0	.0174
19.0	.9455	44.0	.7193	65.0	.4226	90.0	0.0
20.0	.9397	45.0	.7071	66.0	.4067		
21.0	.9336			67.0	.3907		
22.0	.9272			68.0	.3746		
23.0	.9205			69.0	.3584		
24.0	.9135			70.0	.3420		

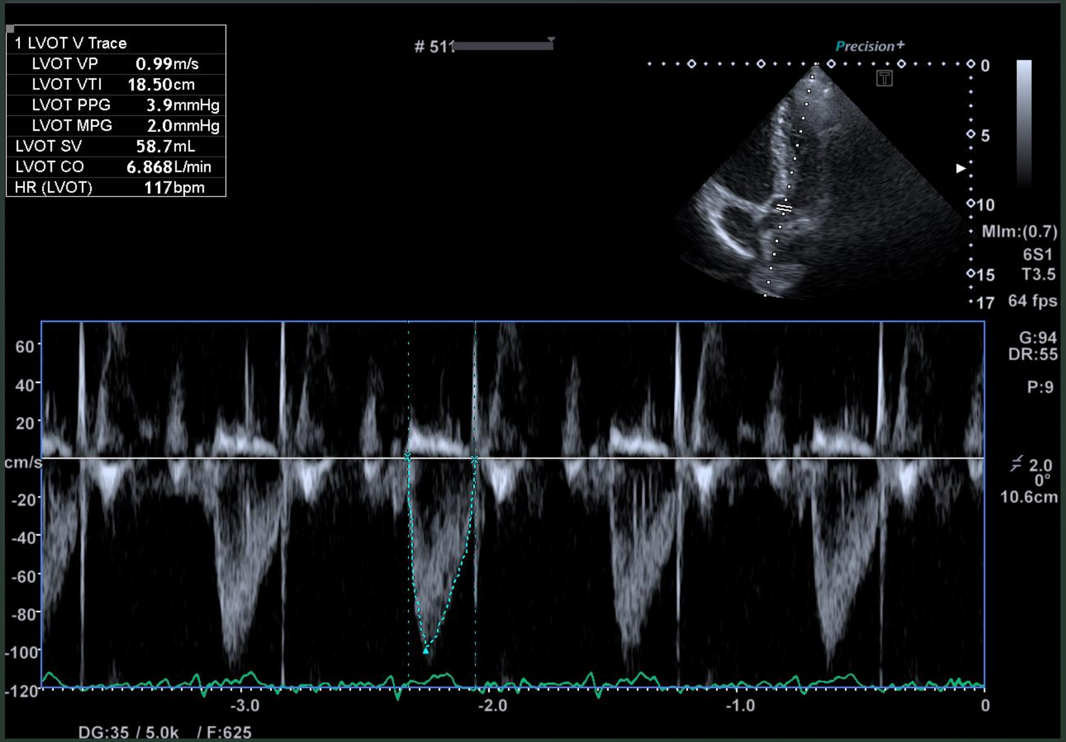


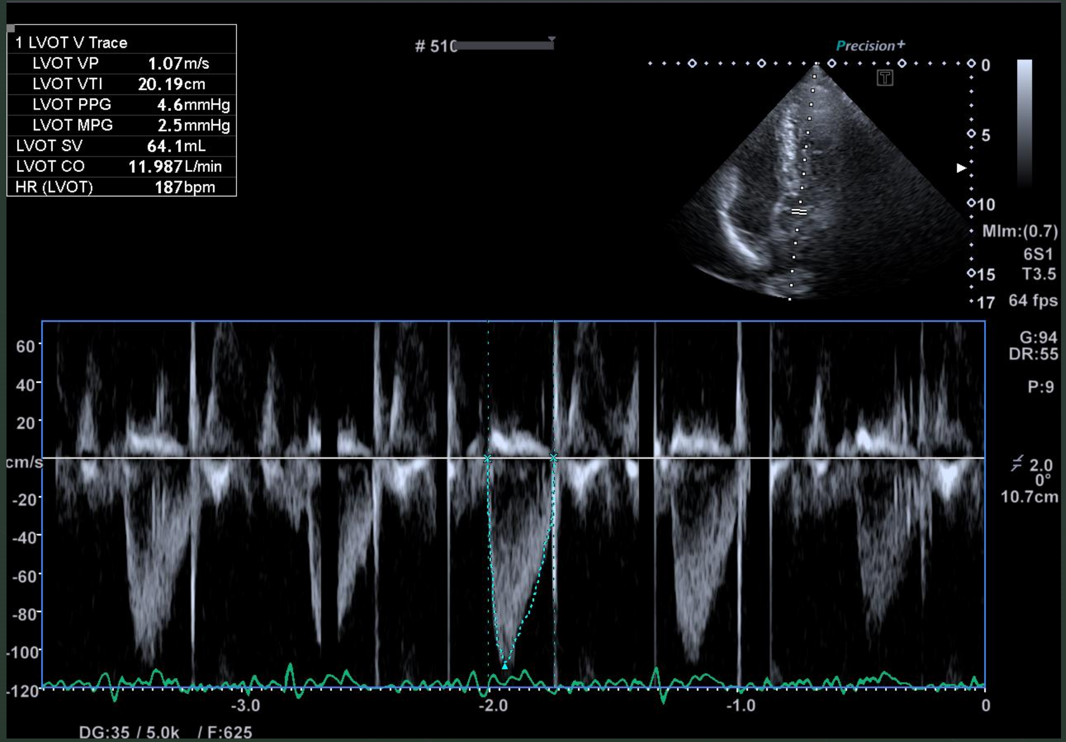
Measurement of the LVOT VTI should always be <20 degrees from the actual direction of blood flow

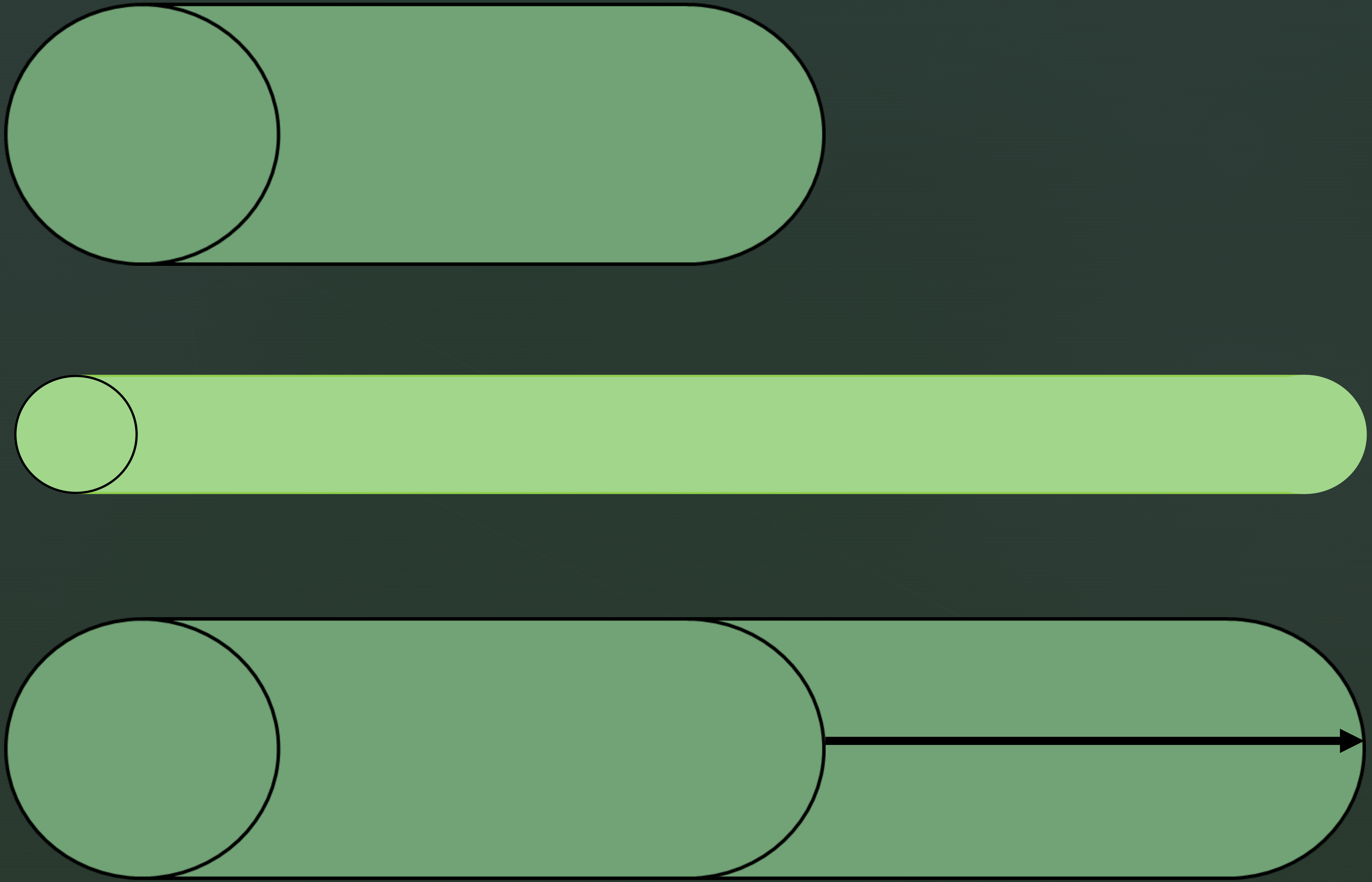


Measurement of the LVOT VTI should always be <20 degrees from the actual direction of blood flow

Improper Gate Placement







How to assess fluid responsiveness with LVOT VTI

- Because the diameter of the LVOT does not change with fluid status, you can omit its measurement if you are only assessing for fluid responsiveness
- There are two methods:
  - 1) Measure the VTI, then give a rapid 250-500 cc bolus, then remeasure the VTI
  - 2) Measure the VTI, then perform a straight leg raise, wait 60-90 seconds, then remeasure the VTI
  - **Subtract the Initial VTI from the final VTI and divide by the average of the two VTI's and convert to a percentage**
    - **>12-15% change in VTI will be fluid responsive**

Fluid responsiveness

- There are only two reasons to give a crystalloid bolus to your patient:
  - You determine their interstitial and/or intracellular compartments to be fluid depleted and they need to be repleted rapidly
  - To increase stroke volume because you believe it will benefit your patient
    - If giving fluids to these patients will not increase the SV, there is no reason to give fluids
    - If the cardiac output is adequate to meet metabolic demands, giving fluids probably doesn’t make much sense either

Straight Leg Raise

The downside of fluids

- The vast majority of crystalloids will be in the interstitial compartment within a few hours (Chowdhury, 2012)
  - Any gain in SV will therefore be transient
- Interstitial fluid causes harm to your patient
  - Renal edema, EVLW, bowel edema, positive fluid balance (Zhang, 2012) (Ueda, 2006) (Boyd, 2011) (FACTT trial, 2006) (Chung, 2008) (Alsous, 2000) (Murphy, 2009)
- Damage to the glycocalyx (Chappell, 2014) (Scicluna, 2009)
  - Generates more interstitial edema
- Venous congestion harms your patient
- Electrolyte abnormalities and acid/base abnormalities (Yunos, 2010)
- From a pathophysiology standpoint, in sepsis, volume depletion is not the problem

References

- Alous et. al., Negative fluid balance predicts survival in patients with septic shock. Chest 2000;117:1749-1754
- Boyd et al., Fluid resuscitation in septic shock: A positive fluid balance and elevated central venous pressure are associated with increased mortality. Crit Care Med 2011;39, no2:259-265
- Chappell et.al., Hypervolemia increases release of atrial natriuretic peptide and shedding of the endothelial glycocalyx. Critical Care 2014, 18:538
- Chowdhury et.al., A randomized, controlled, double-blind crossover study on the effects of 2-L infusions of 0.9% saline and plasma-lyte 148 on renal blood flow velocity and renal cortical tissue perfusion in healthy volunteers. Annals of Surgery 256;1:18-24
- Chung et.al., Impact of extravascular lung water index on outcomes of severe sepsis patients in a medical intensive care unit. Respiratory Medicine (2008) 102,956-961
- FACTT. NEJM 2006;354:2564-75
- Funk, et.al. Crit Care Med 2013;41:255-262
- Jentzer, et.al., Pharmacotherapy update on the use of vasopressors and inotropes in the intensive care unit. Journal of Cardiovasculat Pharmacology and Therapeutics 2015, Vol. 20(3) 249-260
- Murphy, et al., Importance of fluid management in acute lung injury secondary to septic shock. Chest 2009;136:102-109
- Scicluna et.al., Lipopolysaccharide alters vasodilation to natriuretic peptide via nitric oxide and endothelin-1: time-dependent effects. European journal of pharmacology 621 (2009) 67-70
- Ueda et al., Prognostic value of increased plasma levels of brain natriuretic peptide in patients with septic shock. Shock 2006;26, no2:134-13
- Yunos et.al., Association between a chloride-liberal vs chloride-restrictive intravenous fluid administration strategy and kidney injury in critically ill adults
- Zhang, et al. Prognostic value of b-type natriuretic peptide and its potential role in guiding fluid therapy in critically ill septic patients. Scandinavian journal of trauma, resuscitation, and emergency medicine 2012,20:86