01. SUPERIOR VENA CAVA

Echocardiography of the SVC can be done by a transesophageal approach (3).

To remain open, this collapsible vessel must be subject to a distension pressure higher than the critical closing pressure. In a mechanically ventilated patient, the inspiratory phase raises the right atrial pressure less than the pleural pressure.

As a result, the difference between these two pressures, the SVC distension pressure, decreases in the inspiratory phase of assisted respiration and may become insufficient to keep the SVC open in a hypovolemic patient.

Film 1

Film 2

Film 3

Because of an increase in pleural pressure, the SVC behaves like a Starling resistor, and the influence of the external pressure on its diameter is determined by the zone conditions.

We have proposed the use of an SVC collapsibility index calculated as the difference between the maximum expiratory diameter and the minimum inspiratory diameter, divided by the maximum expiratory diameter.

This index can be used to predict the response to fluid administration to a mechanically ventilated patient presenting with signs of circulatory insufficiency (4). This evaluation requires a long-axis view of the SVC (longitudinal view) using a multiplane transesophageal probe (figure 2), operating in two-dimensional M-mode. Our measurements in 66 septic shock patients showed that a collapsibility index above 36% predicted, with 90% sensitivity and 100% specificity, a positive response to volume expansion, marked by significant increase in cardiac flow (4).

Film 4

Film 5

In the same study, we observed a bimodal distribution of collapsibility indices, most patients experiencing complete, or almost complete, inspiratory collapse, or, conversely, presenting with insignificant inspiratory variations in SVC diameter .

We feel that this confirms the parallel drawn with a Starling resistor, which obeys the all-or-nothing rule.

Media

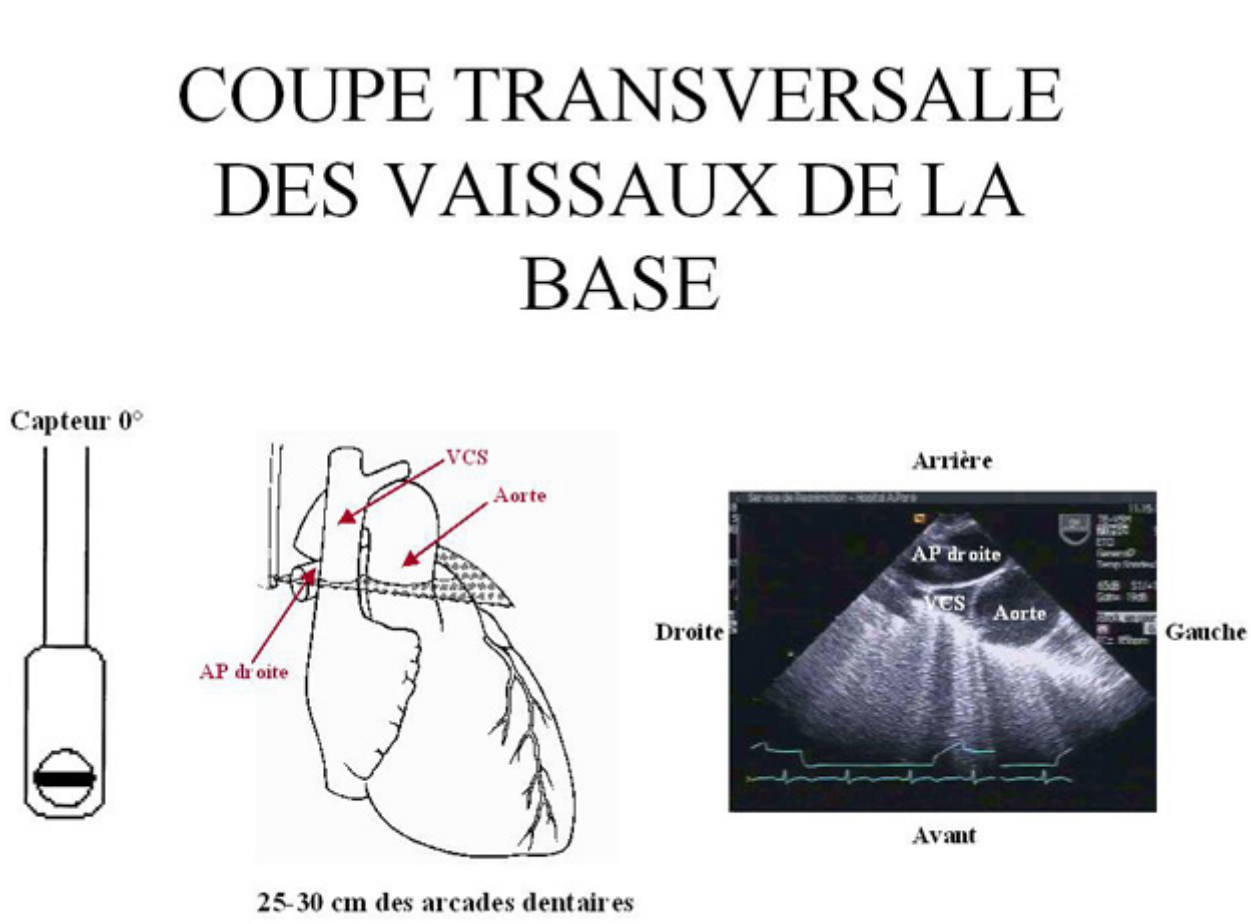


Figure 1 : Transesophageal echocardiography transverse view of the vessels of the base of the heart, through the superior vena cava (SVC). PA: pulmonary artery

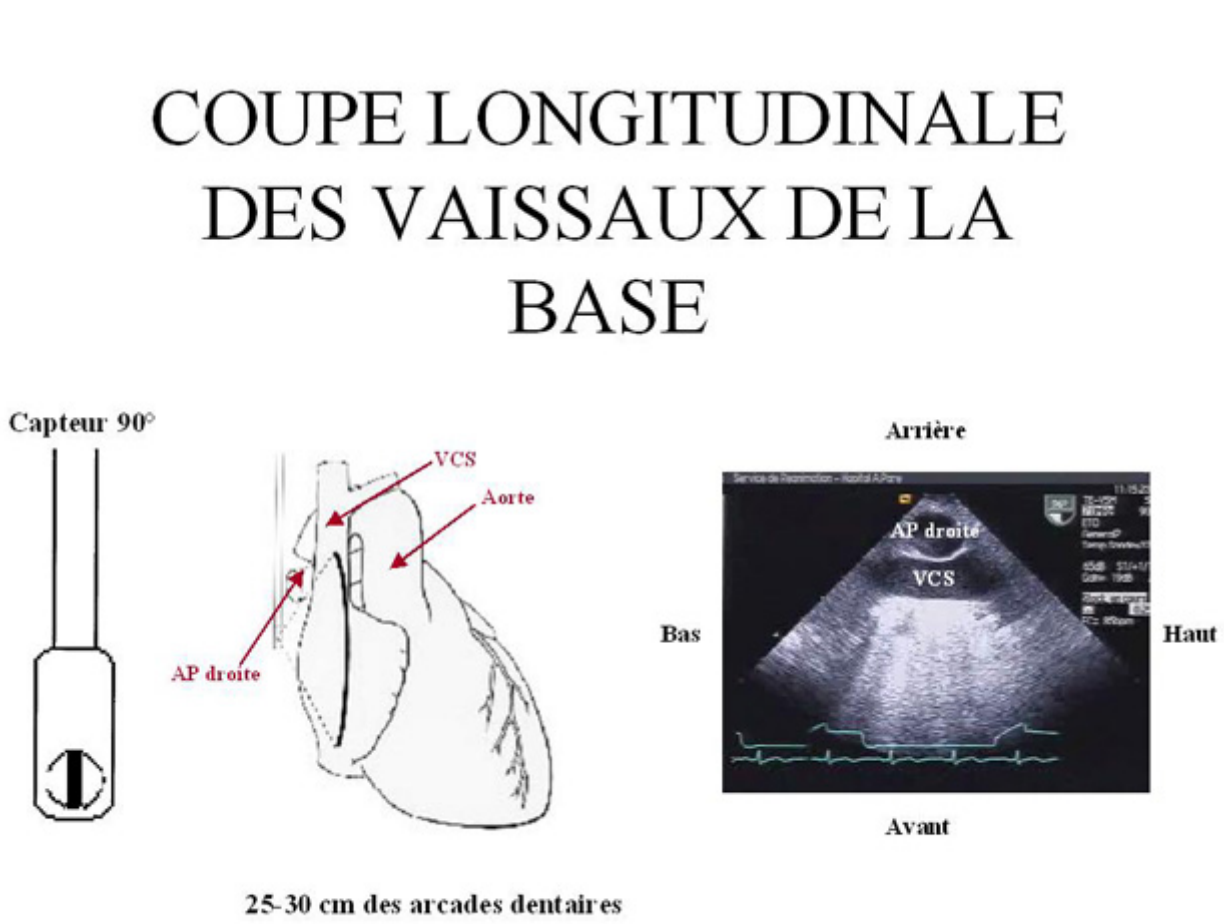


Figure 2 : Longitudinal view of the vessels of the base of the heart, obtained from the transverse view (figure 1) by turning the probe sensor through 90°. This view is used to study respiratory variations in SVC. PA: pulmonary artery

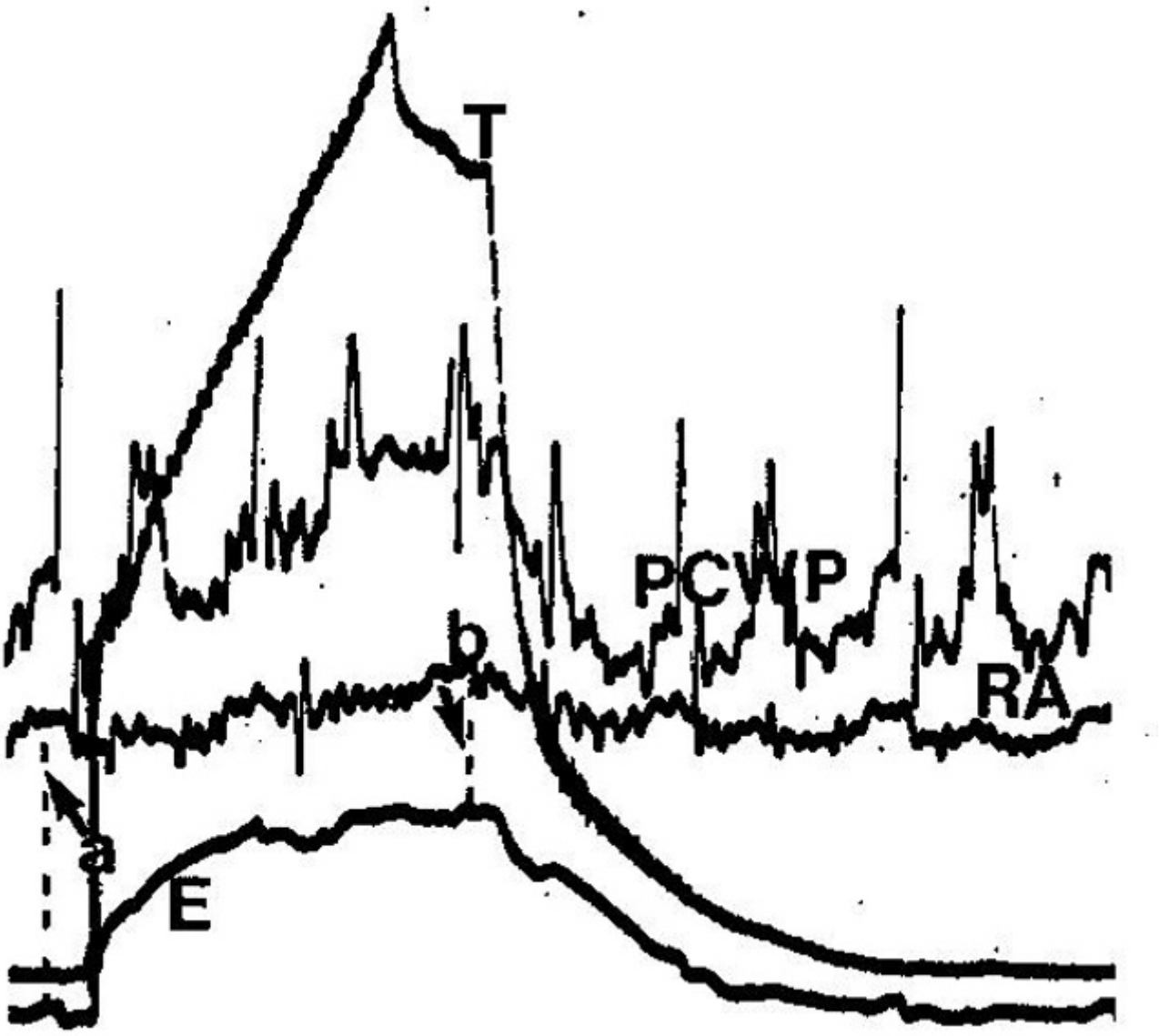


Figure 3 : Simultaneous recording of tracheal pressure (T), pulmonary capillary wedge pressure (PCWP), right atrial (RA) pressure, and esophageal (E) pressure (permitting measurement of pleural pressure). During the inspiration phase, the pleural pressure rises more than the right atrial pressure (or central venous pressure), producing an inspiratory decrease in distension pressure (shown by an arrow)..

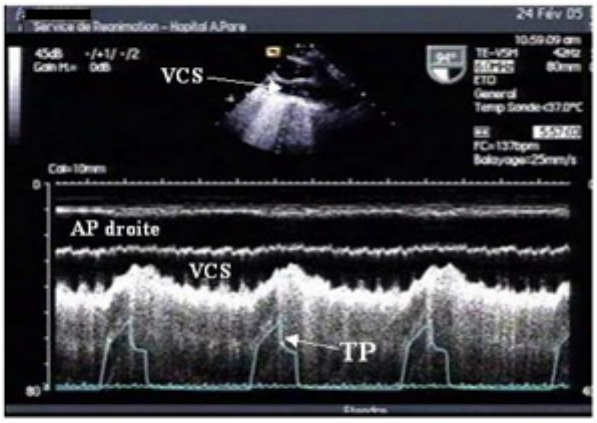


Figure 4 : Partial collapse of the SVC seen on a longitudinal view recorded using two-dimensional and M-mode echocardiography. This recording was made in a mechanically ventilated patient with circulatory insufficiency and suggests the presence of hypovolemia. AP: airway pressure; PA: pulmonary artery.

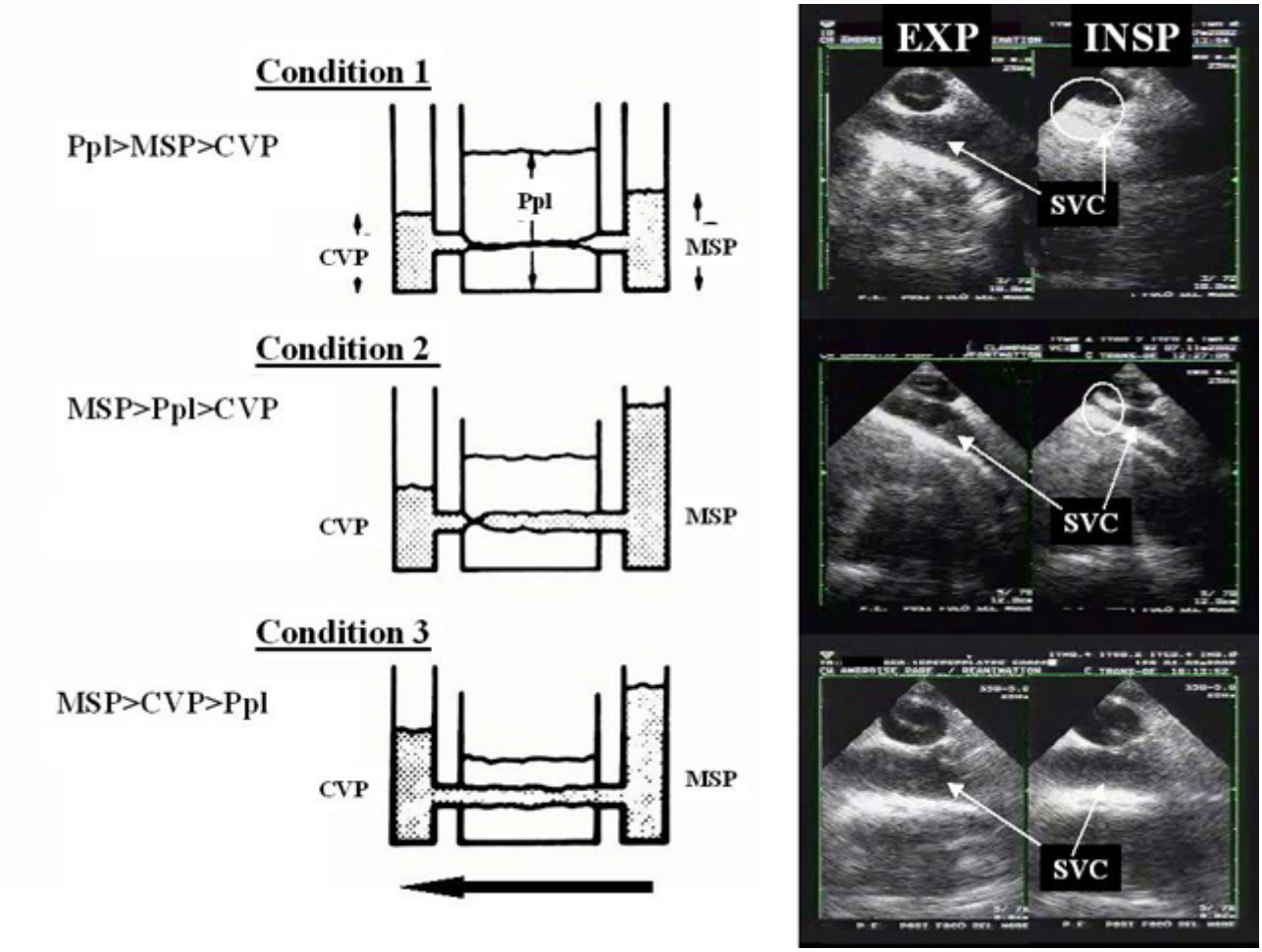


Figure 5 : Left: schematic representation of the SVC as a “Starling resistor’’, with an inflow pressure (mean systemic pressure of the upper part of the body, MSP), an outflow pressure (central venous pressure, CVP), and an external pressure (pleural pressure, PLP). The arrow shows the direction of blood flow. Right, clinical examples illustrating the three zone conditions. Top (condition 1): the inflow pressure drops below the pleural pressure during mechanical pulmonary inflation, which results in complete collapse of the vena cava. This situation is illustrated by examination of a hypovolemic patient. Middle (condition 2): only the outflow pressure is reduced, and pulmonary inflation results in localized collapse at the entry to the atrium. This situation is illustrated by examination after clamping of the inferior vena cava during hepatectomy, which reduces CVP without lowering MSP. Bottom (condition 3): the outflow pressure remains higher than the external pressure, and the vessel remains fully open during pulmonary inflation. This situation is illustrated by examination of the vena cava after volume expansion.
INSP: inspiration; EXP: expiration

Index de collapsibilité VCS = D_{max} - D_{min} / D_{max}

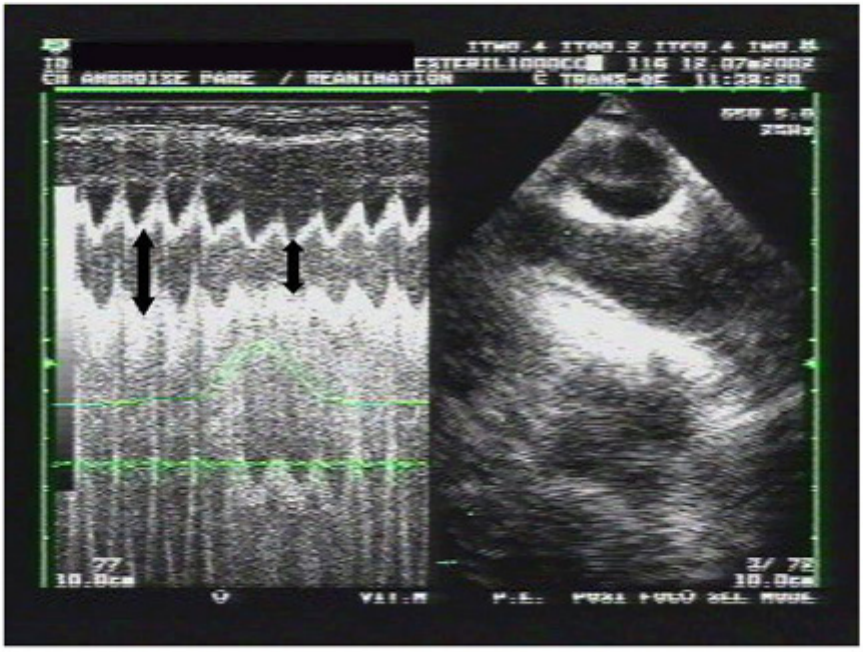


Figure 6 : Measurement of the collapsibility index of the SVC from a longitudinal view (see figure 2), recorded using two-dimensional and M-mode echocardiography. The maximum diameter (Dmax) is observed on expiration, while the minimum diameter (Dmin) is observed at the inspiration plateau.

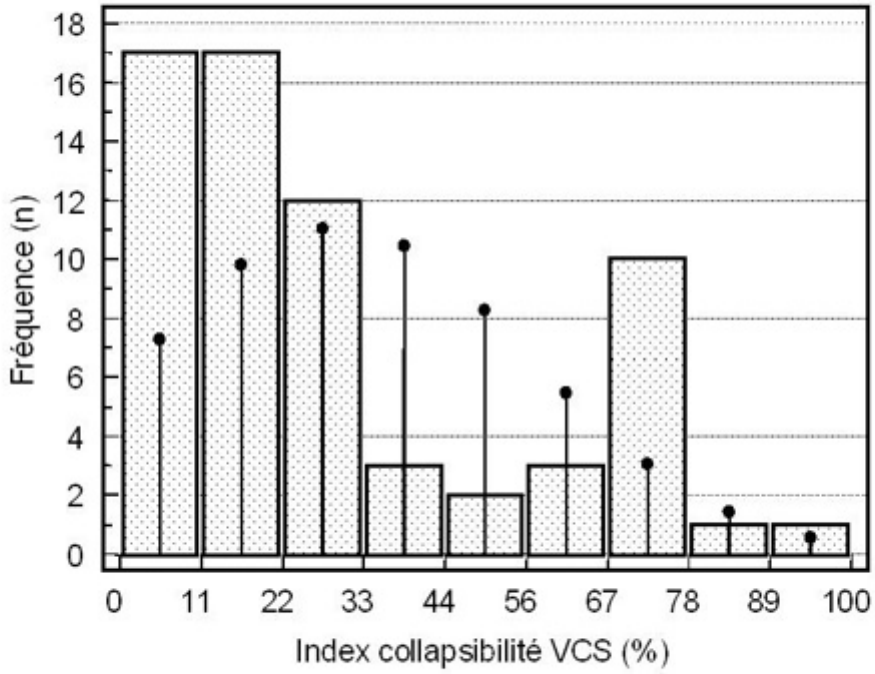


Figure 7 : Distribution of SVC collapsibility index in 66 patients mechanically ventilated because of septic shock. Most of the patients had an index below 30% or above 60%. The vertical lines indicate the normal distribution.