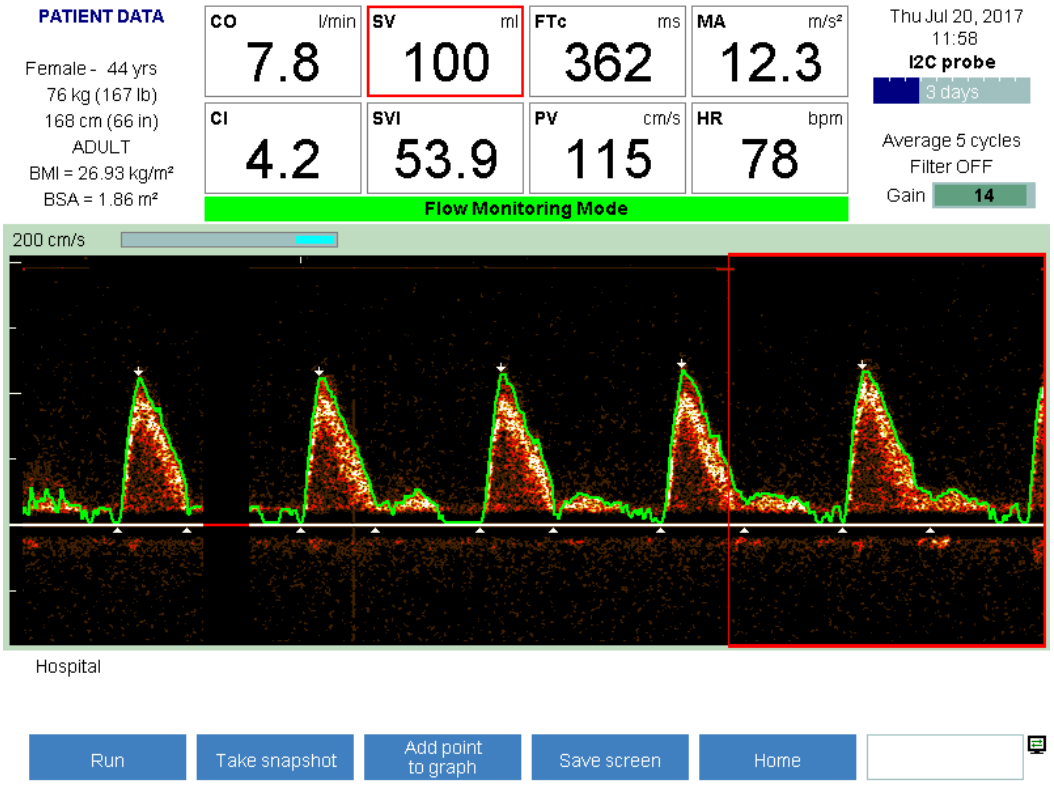
Cytoreductive Surgery and Hyperthermic Intraperitoneal Chemotherapy

A 44 year old female undergoing 10 hour Cytoreductive (CRS) procedure followed by Hyperthermic Intraperitoneal Chemotherapy (HIPEC).

CRS and HIPEC involves a large abdominal incision, extensive peritoneal stripping and highly invasive application of heated chemotherapy to the remaining abdominal contents for an average of 60 minutes. This causes major shifts in blood fluid, blood pressure, coagulation, respiratory, electrolytes and body temperature. Due to the significant dilatation effects of HIPEC these patients lose fluids and are often hypotensive. It is therefore essential to be able to accurately monitor and differentiate between both blood pressure and blood flow. This enables the clinician to confidently manage the multiple interventions required to ensure optimal organ perfusion.

ODM+ is uniquely designed to guide both the fluids and vasoactive drugs during this procedure, utilising the combination of technologies available within the device. Oesophageal Doppler directly and accurately measures the blood flow and enables the clinician to intervene using the Doppler-specific 10% stroke volume algorithm for fluids as well as to titrate vasoactive agents and inotropes. The timing, balance, and interaction of both fluids and drugs is critical in these cases. The calibrated pulse pressure algorithm is ideal to provide longer term monitoring and when diathermy interferes with the ultrasound signal. High Definition Impedance CardioGraphy (HD-ICG) can then be used after surgery to ensure the patient is not hyper or hypovolaemic 48 hours post operatively.

Screenshot 1 – CRS Patient Optimised



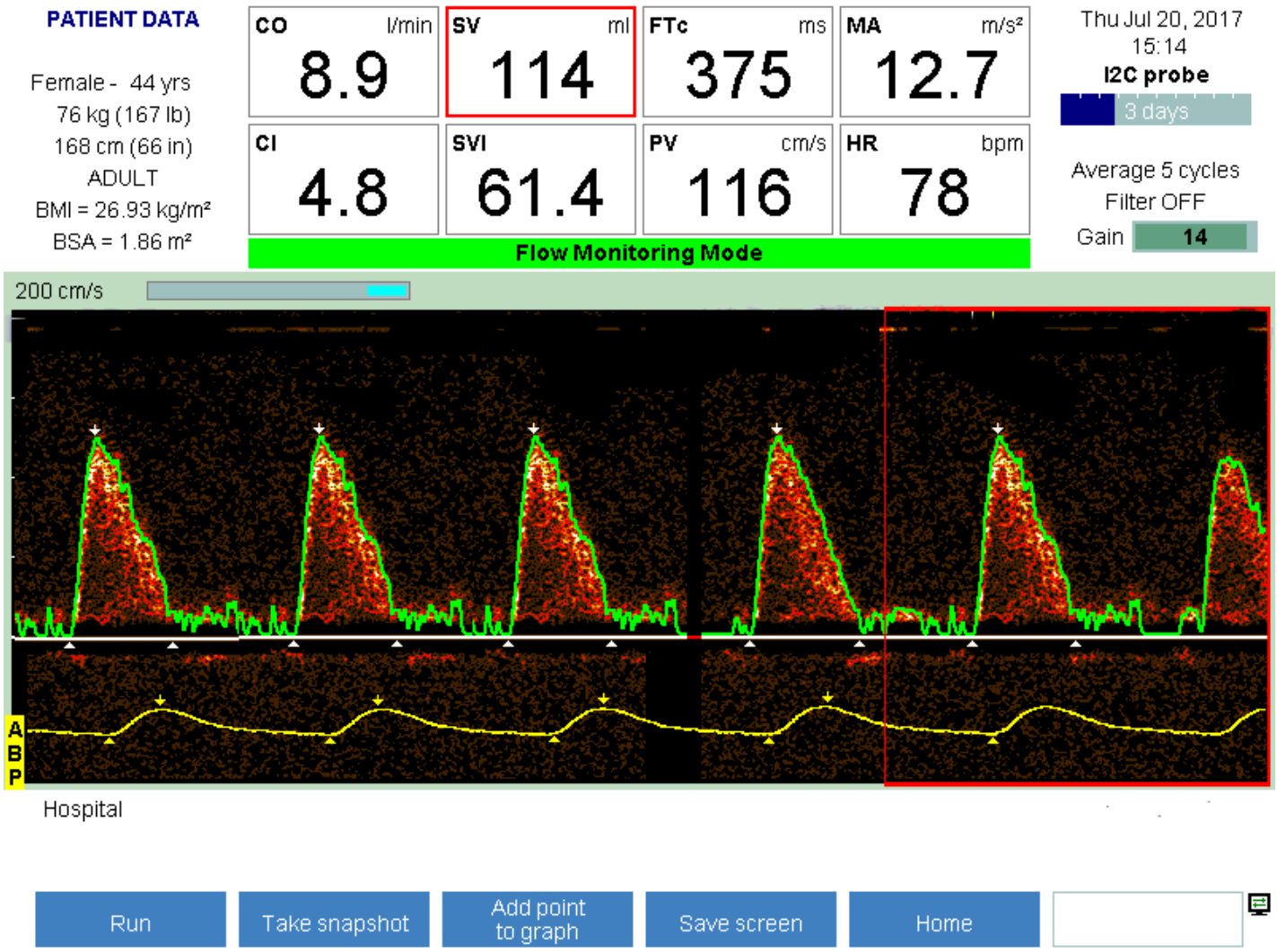
For abbreviations see Appendix 1

Blood loss during CRS is minimal so the first objective is to get the patient fluid optimised at the start of surgery, understanding that the up-coming interventions will cause significant shifts in haemodynamics. Most of these patients are young, (<50 years old) and are usually cardiovascularly fit.

During both the CRS and especially in HIPEC the patient can be hypotensive (MAP <65) and phenylephrine is typically given. Phenylephrine will increase blood pressure, but due to the nature of this drug it can also significantly decreases cardiac output (CO) and stroke volume (SV), so it is therefore vital to be able to accurately measure and visualise the patient's blood flow before administering this drug.

The ODM+ is unique as it provides real time information on the patient's CO and SV as well as information on contractility (PV) and afterload (FTc) which can all change when vasoactive drugs are given.

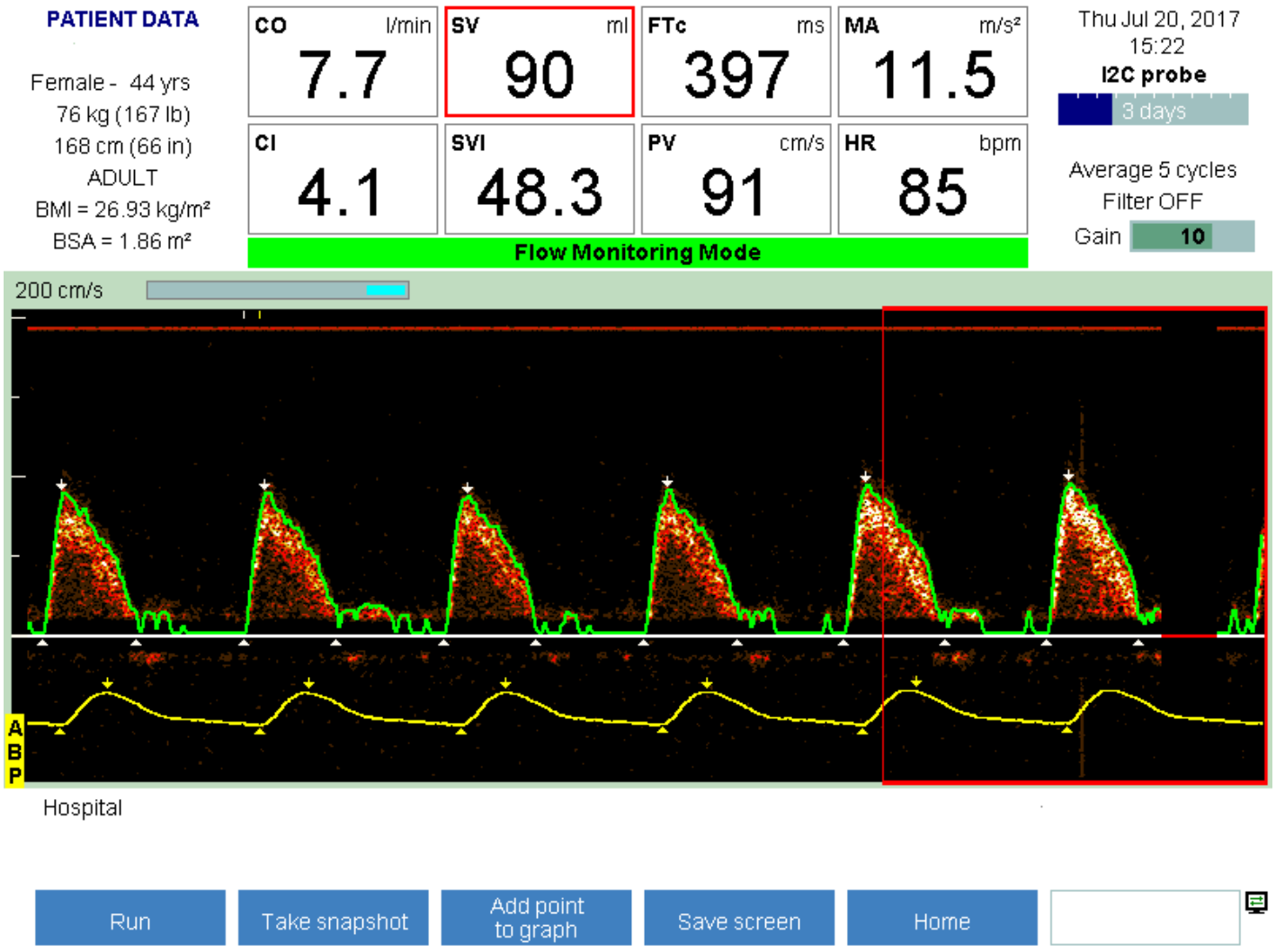
Screenshot 2 – Haemodynamics Before Phenylephrine Infusion



For abbreviations see Appendix 1

Managing blood pressure is very important during the procedure and understanding the impact on blood flow is very important. This patient became hypotensive (MAP <60) so phenylephrine was administered. The screenshot above shows the CO and SV before the infusion was started.

Screenshot 3 – Haemodynamics After Phenylephrine Infusion

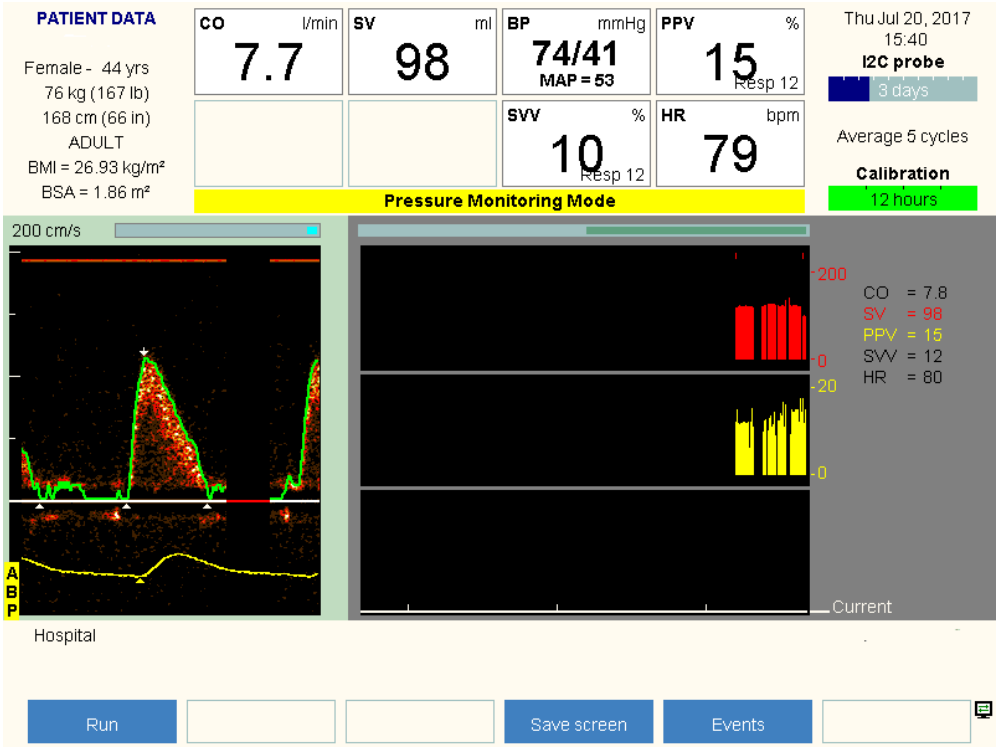


For abbreviations see Appendix 1

The screenshot above was taken 8 minutes after phenylephrine infusion was started – MAP and HR increases to try to maintain CO, but SV and PV has reduced by 20%. This is where it is critical to utilise the ODM+ which accurately identifies this reduction, compared to technologies that use blood pressure waveform analysis alone, that will show SV increasing at this point Blood pressure derived algorithms incorrectly assume a rise in blood pressure means a rise in SV.

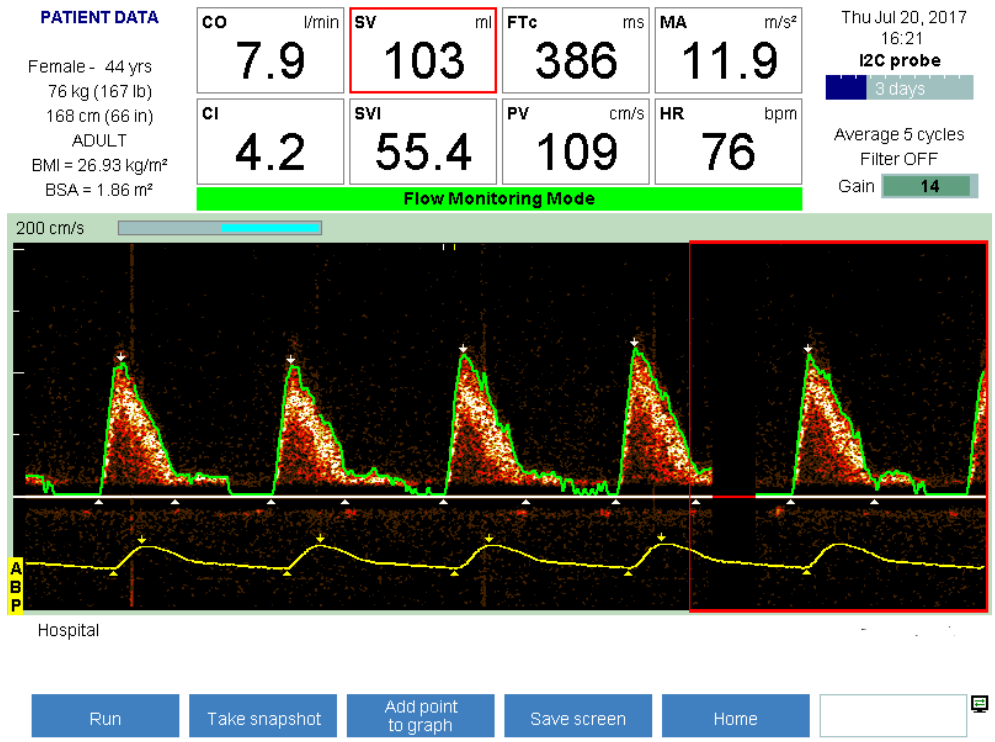
There is a lot of diathermy during CRS so the clinician also used the arterial line and the ODM calibrated pulse pressure waveform analysis (PPWA) on the ODM+ to monitor the patient. When interventions are required the screen can be switched back to the Doppler flow based parameters.

Screenshot 4 - Pressure Monitoring Mode - End of CRS



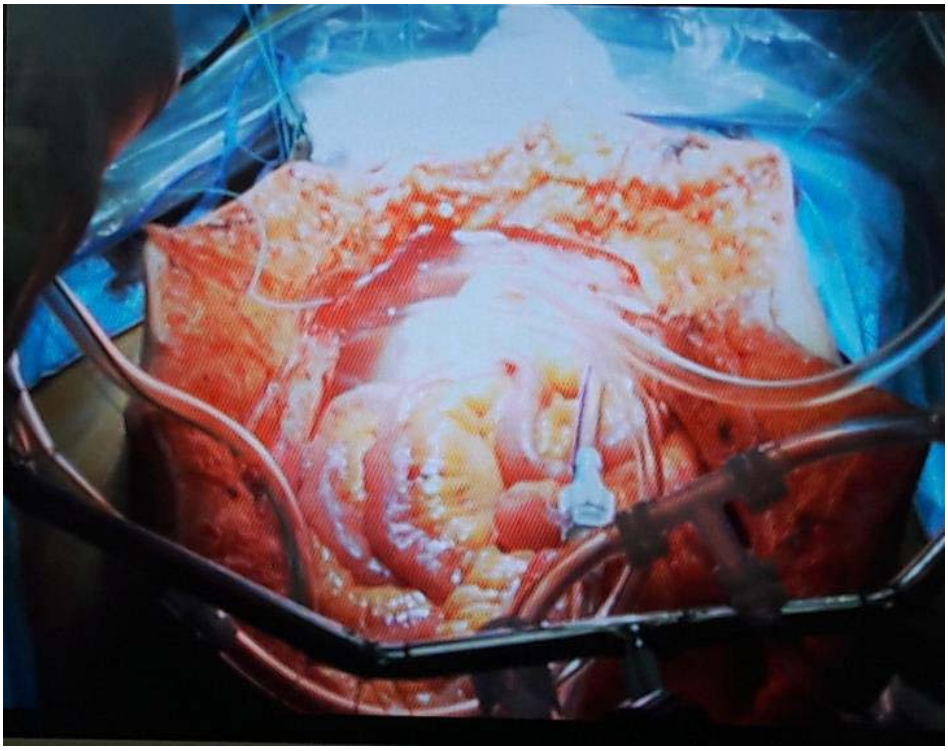
This screenshot was taken at the end of CRS procedure and the patient has been maintained at the same optimised level, using ODM+ to manage both the fluid boluses and vasoactive drugs as appropriate.

Screenshot 5 - Pressure Monitoring Mode - End of CRS

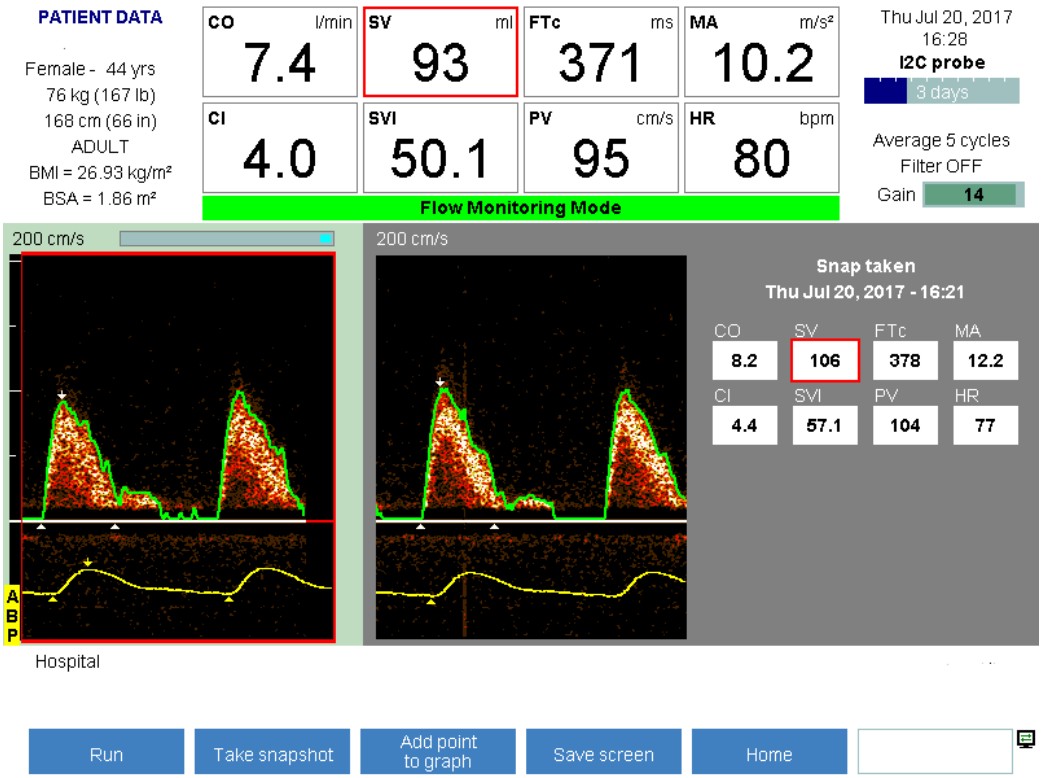


At the start of HIPEC the fluid was pumped into the abdominal cavity using the Sun Chip HIPEC system, which caused an increase in intra-abdominal pressure and impairment of venous return. It is very important at this stage to have insight into the actual components of SV such as Flow Time corrected (FTc) and Peak Velocity (PV).

Screenshot 6 – HIPEC Begins



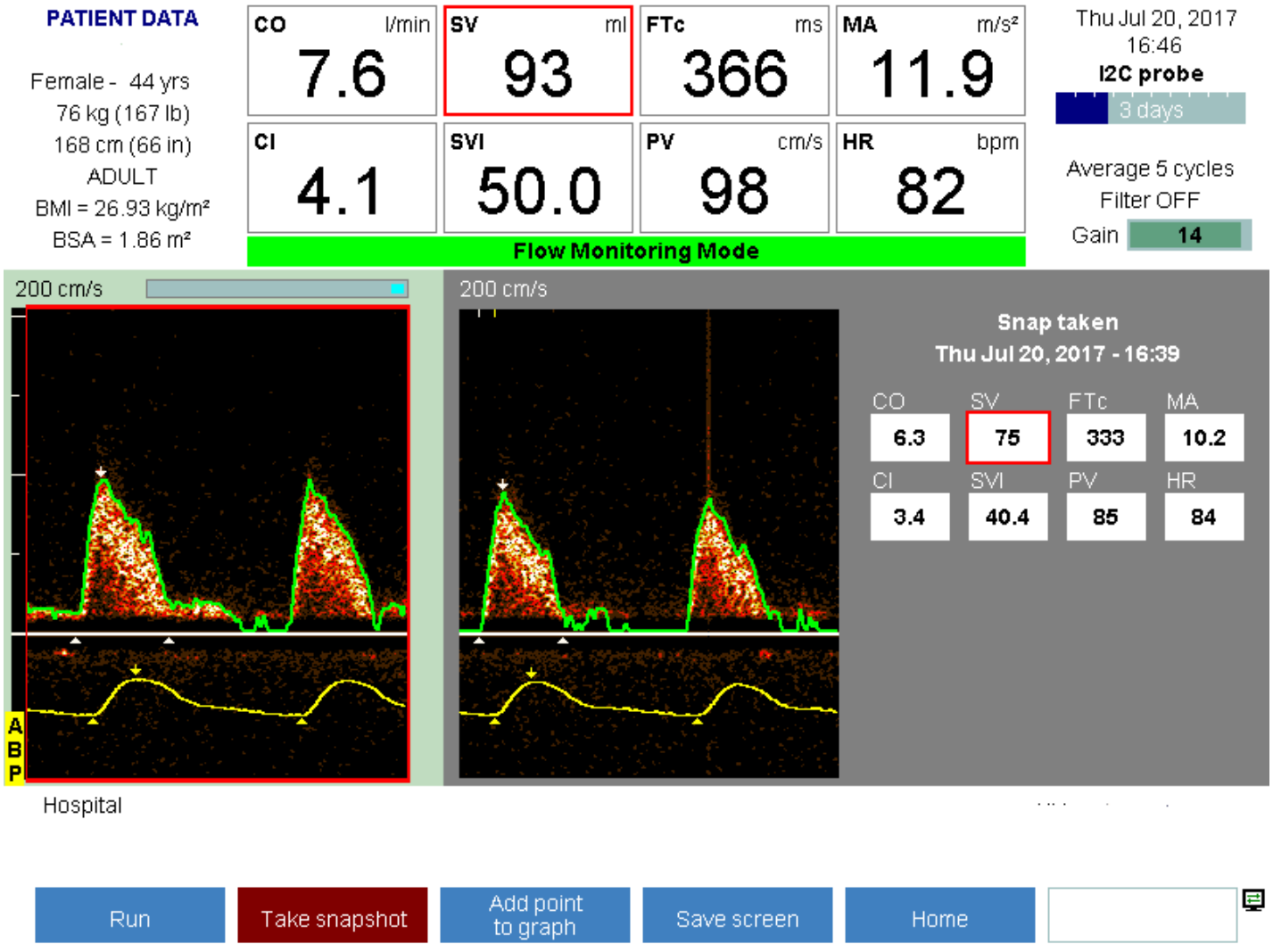
The screenshot below shows the reduction in SV, CO, PV and FTc caused by 3 litres of saline being pumped into the abdominal cavity impacting venous return.



During HIPEC there are major shifts in haemodynamics caused by blood loss, blood pressure changes, the depth of anaesthesia and levels of pain control. However, the biggest impact is the introduction of the hyperthermia solution at temperatures of 39-42°C which induces a hypermetabolic state and significant peripheral vasodilation, which is reflected in FTc.

Screenshot 7 shows before and after a rapid 250 ml fluid challenge. At 16.39 the patient's SV had dropped to 75 and 7 minutes after the fluid bolus was given the SV increased back to 93.

Screenshot 7 – Before and After a Fluid Challenge



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Summary

Clinical studies recommend that a liberal approach to fluid management is the best approach during CRS and HIPEC. However, with major shifts in both blood flow and blood pressure this procedure should not be done without using advanced haemodynamic monitoring to accurately manage the timing and response. Fluid loading blindly, towards the end of CRS and at the start of HIPEC, will have a negative impact on the patient's long-term recovery.

Using technologies that rely solely on the analysis of blood pressure to derive a blood flow estimate could also be dangerous in these patients. They can give false readings when blood pressure is increasing either when, vasoactive drugs are given, or due to intra-abdominal pressure from the hyperthermic fluid reducing venous return.

For example, if at the beginning of HIPEC the pressure-based monitors are recording increases in SV and CO in line with increased blood pressure, it is possible that no more fluid will be administered. The patient *could* be hypovolaemic, due to the losses caused by peripheral dilatation and increasing systemic oxygen demand.

The CardioQ-ODM+ is the only device that measures *flow, pressure and impedance.* Therefore it can be utilised to ensure the patient is normovolaemic throughout. As such the patient receives neither too much nor too little fluid during this very challenging procedure.

Appendix

Abbreviations:

CO - cardiac output	SV - stroke volume	FTc - flow time corrected	
CI - cardiac index	SI - stroke index	PV - peak velocity	HR - heart rate
BP - blood pressure	CVP - central venous pressure	BMI - body mass index area	BSA - body surface area

Doppler parameter details:

FTc - duration of flow during systole and is inversely affected by afterload. Normal range in a resting healthy individual approximately 330-360ms. If afterload is increasing, FTc is likely to reduce and vice versa. Most common cause of a low FTc is hypovolemia - a low circulating blood volume causes vasoconstriction and subsequent reduced FTc. A high FTc is seen in low resistance/afterload states such as sepsis or anaesthesia.

PV - can be a good indicator of contractility but is affected by load and age. The shape of the waveform can indicate left ventricular function - more upright waveforms usually indicate good ventricular function whereas a flatter waveform usually indicates reduced ventricular function.