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"Beyond Blood Pressure: FloTrac for Advanced Hemodynamic Assessment and Nursing Decision-Making"

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Abstract

FloTrac is a minimally invasive hemodynamic monitoring system used to assess real-time cardiovascular status by continuously measuring cardiac output and other key parameters through arterial waveform analysis. It is widely utilized in critically ill and perioperative patients where rapid assessment of fluid status, tissue perfusion, and cardiac function is essential. FloTrac is based on pulse contour analysis, in which the arterial pressure waveform is analysed to estimate stroke volume and cardiac output without the need for pulmonary artery catheterization. The system integrates patient demographic data with arterial waveform characteristics to calculate dynamic parameters such as stroke volume variation and systemic vascular resistance. Indications for FloTrac monitoring include shock states, major surgeries, sepsis, trauma, acute heart failure, and patients requiring goal-directed fluid therapy. Initial setup of the FloTrac system includes sensor connection, patient data entry, calibration requirements, and monitor view highlights the continuous and intermittent parameters measured, including cardiac output, cardiac index, stroke volume, stroke volume variation, systemic vascular resistance, and other advanced hemodynamic variables. It also demonstrates essential nursing competencies such as the process of zeroing the FloTrac system and performing intermittent transpulmonary thermodilution (TPTD) monitoring for enhanced accuracy in selected patients. Thus, FloTrac provides an effective, rapid, and reliable approach to hemodynamic monitoring, supporting nurses and clinicians in early detection of instability and evidence-based decision-making. Nursing Skills are essential for reinforcing the importance of correct setup, interpretation, and nursing vigilance in maximizing patient safety and outcomes.

Keywords: *FloTrac, cardiac output monitoring, arterial waveform analysis, stroke volume variation, Volume-View, transpulmonary thermodilution, hemodynamics, critical care nursing.*

INTRODUCTION

Hemodynamic instability is a frequent and life-threatening problem in critically ill and perioperative patients. Accurate assessment of cardiac output, circulating volume status, and vascular tone is essential for timely resuscitation and prevention of organ hypoperfusion (Marino, 2014). Traditional invasive monitoring such as pulmonary artery catheterization provides detailed cardiovascular information; however, it is highly invasive and associated with complications including arrhythmias, infection, thrombosis, and pulmonary artery rupture (Vincent & Rhodes, 2010). To overcome these limitations, minimally invasive hemodynamic monitoring devices such as the FloTrac system have become widely used. FloTrac provides continuous estimation of cardiac output and dynamic parameters using arterial waveform analysis. This supports goal-directed therapy

(GDT) and improves clinical decision-making in critical care and high-risk surgical patients (Cecconi et al., 2014; Michard & Teboul, 2002). Furthermore, FloTrac displays both continuous and intermittent hemodynamic measurements, allowing clinicians to evaluate oxygen delivery and the balance between oxygen delivery and oxygen consumption.

This manuscript is a descriptive review of the FloTrac hemodynamic monitoring system, including its mechanism of action, required equipment, setup procedure, display options, measured parameters, and limitations. Information was compiled from standard critical care references and published literature on hemodynamic monitoring and goal-directed therapy.

Description of FloTrac System

The FloTrac system continuously analyzes the patient's arterial pressure waveform to estimate cardiac output and other hemodynamic parameters. The monitor displays real-time values and updates continuously.

Continuous parameters (arterial waveform-based)

Using an arterial line and an Edwards FloTrac sensor, the monitor provides continuous hemodynamic values including:

- Cardiac output (CO)
- Stroke volume (SV)
- Stroke volume variation (SVV)

When combined with a TruWave transducer for central venous pressure (CVP) monitoring, the system can also calculate:

- Systemic vascular resistance (SVR)

Intermittent parameters (Volume-View transpulmonary thermodilution-based)

For intermittent advanced hemodynamic monitoring, FloTrac requires:

- VolumeView catheter placed in the femoral artery
- Central venous catheter (CVC) with thermistor manifold
- Central venous pressure (CVP) measurement

Intermittent parameters include:

- Intermittent cardiac output (iCO)
- Intermittent stroke volume (iSV)
- Intermittent systemic vascular resistance (iSVR)
- Global end-diastolic volume (GEDV)
- Extravascular lung water (EVLW)

Mechanism of Working

FloTrac uses arterial pressure waveform analysis to estimate stroke volume and cardiac output. Patient demographic data such as age, gender, height, and weight are entered into the monitor to determine patient-specific vascular compliance. The FloTrac sensor detects variations in arterial pressure, which are proportional to stroke volume. The system compensates for changes in vascular compliance and vascular resistance, allowing continuous hemodynamic estimation without manual calibration.

FloTrac Sensor

The FloTrac sensor is a sterile, single-use device designed for invasive pressure monitoring systems. It includes a straight flow-through design across the pressure sensors, an integral flush device, and a bedside setup process similar to standard arterial pressure monitoring.

Indications

FloTrac monitoring is primarily indicated in critically ill and high-risk surgical patients in whom the balance between cardiac function, fluid responsiveness, and vascular resistance requires continuous or intermittent assessment.

Initial Startup and Setup Procedure

Articles required

A standard setup tray should include:

- FloTrac sensor and tubing
- Sterile gloves
- 20 mL syringe
- Cold saline (for thermodilution)
- Pressure bag
- VolumeView femoral artery catheter
- VolumeView sensor
- Central venous catheter (CVC)
- VolumeView manifold
- TruWave disposable transducer for CVP

Setup includes the following steps:

1. Connect the primed FloTrac sensor to the Databox.
2. Connect primed FloTrac pressure tubing to the arterial catheter (radial or femoral).
3. If SVR/SVRI monitoring is required, connect primed CVP tubing to the CVC.
4. Enter patient demographic data via Settings → Patient Data.
5. Select the desired monitoring screen using Monitor Screen Selection.

6. Begin monitoring.

Monitor Display Options

All monitoring functions are initiated through the touch screen. The display is organized into three major bars:

1- Navigation bar

The navigation bar provides access to:

- GDT tracking menu
- Monitor screen selection
- Clinical actions
- Settings
- Snapshot
- Alarm silencing

2- Information bar

The information bar appears on all active monitoring screens and includes:

- Current time and date
- Battery status
- Screen lock symbol
- Physio interval status

3- Status bar

The status bar appears at the bottom of monitoring screens and displays:

- Faults
- Alarms
- Alerts
- Warnings and notifications

Monitor Views

FloTrac provides seven monitoring views:

1. Graphical trend
2. Tabular trend
3. Big numbers
4. Physiology
5. Cockpit
6. Goal positioning
7. Physio relationship

Up to four monitored parameters can be displayed at a time.

Hemodynamic Parameters Measured

FloTrac continuous parameters

- Cardiac output (CO): CO = SV × HR
- Cardiac index (CI): CI = CO / BSA
- Stroke volume (SV)
- Stroke volume index (SVI)
- Systemic vascular resistance (SVR): SVR = (MAP − CVP) × 80 / CO
- Systemic vascular resistance index (SVRI)
- Stroke volume variation (SVV): SVV = 100 × (SVmax − SVmin) / mean SV

Abnormal Value	Inference	Nursing Priority
↓ **CO/CI**	Poor perfusion	verify line + notify + prepare inotrope/fluids
↑ **SVV**	Fluid responsive	fluid bolus + reassess
↓ **SVV**	fluid unresponsive	avoid bolus, assess SVR/contractility
↓ **SVR**	Vasodilation	vasopressor support
↑ **SVR**	Vasoconstriction	review vasopressors + check CO
↑ **EVLW**	Pulmonary edema	restrict fluids + diuretics/CRRT + respiratory care
↓ **CFI/GEF**	Low contractility	inotropes + avoid overload

Keys: CO – Cardiac Output, CI – Cardiac Index, SVV – Stroke Volume Variation, SVR – Systemic Vascular Resistance, EVLW – Extravascular Lung Water, CFI – Cardiac Function Index, **GEF** – Global Ejection Fraction.

Volume-View intermittent parameters

- Cardiac function index (CFI): CFI = 1000 × CO / GEDV
- Intermittent cardiac output (iCO)
- Extravascular lung water (EVLW)
- Extravascular lung water index (ELWI)
- Global ejection fraction (GEF)
- Global end-diastolic volume (GEDV)
- Global end-diastolic volume index (GEDI)
- Intrathoracic blood volume (ITBV)
- Pulmonary vascular permeability index (PVPI)

Zeroing Procedure (Continuous Monitoring)

Zeroing is essential for accuracy and should be performed as follows:

1. Level the transducer at the patient's phlebostatic axis.
2. Select Clinical Actions → Zero & Waveform.
3. Zero each transducer individually or select Zero All.
4. Open transducers "ON" to the patient.
5. Confirm appropriate waveforms.
6. Press Home to begin monitoring.

Volume-View Intermittent Monitoring (Transpulmonary Thermodilution)

Transpulmonary thermodilution (TPTD) provides hemodynamic parameters related to blood flow, fluid volume, cardiac function, and organ perfusion.

A known volume of cold injectate is delivered through a CVC, passes through the pulmonary circulation and left heart, and is detected by a thermistor in the femoral artery catheter.

Procedure:

1. Connect a pre-chilled saline syringe to the VolumeView manifold port.
2. Select Clinical Actions → Thermodilution.
3. Select injectate volume (up to 20 mL).
4. Touch Start Set and wait for baseline.
5. When Inject appears, inject rapidly and smoothly.
6. Repeat measurements if required using a fresh chilled syringe.

Role of Nurses in FloTrac-Guided Hemodynamic Management

- FloTrac monitoring is a bedside nursing procedure used to continuously track cardiac output and fluid responsiveness using an arterial line waveform.
- The nurse primes the FloTrac tubing with normal saline, removes all air bubbles, inflates the pressure bag to 300 mmHg, and connects the FloTrac sensor to the Databox and the patient's arterial catheter (radial/femoral).
- The transducer is leveled at the phlebostatic axis and zeroed on the monitor to ensure accurate readings.
- After entering patient details (age, height, weight, gender), the nurse confirms a good arterial waveform and begins monitoring values such as CO/CI, SV, SVV, MAP, and SVR (if CVP is connected).
- During monitoring, the nurse frequently checks for damped waveforms, loose connections, kinks, clots, or air bubbles, because these can give false readings.
- The nurse correlates FloTrac trends with patient condition (urine output, mentation, skin perfusion, lactate, blood pressure)
- Informs the physician if CO falls, SVV rises, or perfusion worsens.

- If Volume-View thermodilution is ordered, the nurse injects cold saline rapidly through the CVC when the monitor prompts "Inject" and records intermittent values like GEDV and EVLW.
- Continuous observation, prompt troubleshooting, infection control, and clear documentation of trends and interventions are the key practical nursing responsibilities in FloTrac monitoring.

Steps of Procedure

S.No.	Items	Yes	No
	Pre-Procedure		
1.	Checks doctor's order		
2.	Ensures privacy and patient safety (side rails, position)		
	Intra-Procedure		
3.	**Equipment Preparation**		
	a) Collects FloTrac sensor + pressure tubing		
	b) Collects sterile gloves and sterile tray		
	c) Collects pressure bag + NS flush setup		
	d) Collects 20 mL syringe + cold saline (for TPTD if ordered)		
	e) Ensures arterial line access (radial/femoral) is available		
	f) Ensures central venous catheter available for CVP/TPTD		
4.	**FloTrac Setup and Connections**		
	a) Performing hand hygiene and wear sterile gloves		
	b) Primes FloTrac tubing correctly		
	c) Connect FloTrac sensor to Databox/EV1000 correctly		
	d) Connect pressure tubing to arterial catheter using aseptic technique		
	e) Ensures pressure bag inflated to 300 mmHg		
	f) Secures connections and checks for leaks		
	g) Ensures arterial waveform appears on monitor		
	h) Perform Transducer Leveling and Zeroing		
5.	Enter Patient's age, Sex, height and weight correctly		
6.	Identifies Parameters Correctly		
7.	Assesses arterial waveform for damping issues		
8.	Ensures continuous patency of arterial line		
9.	Monitors limb perfusion (esp. femoral line)		
10.	Maintains strict asepsis for all lines		
11.	Monitors trends (CO/SV/SVV/SVR) rather than single values		
12.	Correlates values with patient perfusion (UO, mentation, lactate)		
13.	Identifies abnormal values and reports promptly		
14.	Documents hemodynamic values and interventions		
15.	Maintains strict asepsis for all lines		
	Post-Procedure care		
16.	Ensures patient comfortable and safe		
17.	Disposes waste safely (sharps + biomedical waste)		
18.	Removes gloves		
19.	performs hand hygiene		
20.	Ensures alarms are active and set appropriately		

Clear documentation of all interventions required in FloTrac monitoring are the practical nursing responsibilities used extensively in ICUs as advanced Nursing Procedure.

Nursing Interventions for Abnormal FloTrac Values

Abnormal Value	Inference	Priority Nursing Interventions
↓ **CO/CI**	poor perfusion	Check waveform/zero/level first Assess MAP, UO, mentation, lactate Check ECG rhythm Look for bleeding/fluid loss Inform doctor Prepare fluids/inotropes/vasopressors as ordered
↑ **SVV**	fluid responsive	Confirm SVV validity Assess hypovolemia signs Prepare fluid bolus as ordered Reassess SV, CO, MAP, UO Watch for overload
↓ **SVV**	fluid unresponsive	Avoid unnecessary bolus Assess SVR + contractility (CFI/GEF) Prepare vasoactive adjustment Monitor lungs and fluid balance
↓ **SVR**	Vasodilation	Assess MAP/perfusion Sepsis bundle actions as ordered Prepare vasopressors (norepinephrine) Monitor UO hourly Maintain strict I/O
↑ **SVR**	vasoconstriction	Check CO/CI (may fall) Assess cold extremities, cap refill Review vasopressor dose Treat pain/anxiety/hypothermia Prepare dose adjustment/fluids as ordered
↑ **EVLW** / ↑ **ELWI**	pulmonary edema	Monitor SpO_2, ABG, FiO_2 requirement Auscultate lungs Restrict fluids Prepare diuretics/CRRT Support ARDS care (PEEP/proning readiness)
↓ **CFI** / ↓ **GEF**	low contractility	Monitor for cardiogenic shock Avoid excess fluids unless GEDV low Prepare inotropes as ordered Continuous ECG monitoring Optimize oxygen delivery (Hb + oxygenation)

CO – Cardiac Output, **CI** – Cardiac Index, **SVV** – Stroke Volume Variation, **SVR** – Systemic Vascular Resistance, **EVLW** – Extravascular Lung Water, **CFI** – Cardiac Function Index, **GEF** – Global Ejection Fraction.

General Nursing Troubleshooting

If values suddenly change or don't match the patient's condition:

Immediate Checks

- Check transducer leveling at phlebostatic axis
- Re-zero if needed
- Check waveform:
  - Overdamped/underdamped
  - Kinks, air bubbles, clots
- Check arterial catheter site and patency
- Confirm correct patient demographic entry

Note: Incorrect setup is one of the most common reasons for abnormal readings.

DISCUSSION

FloTrac has emerged as an important minimally invasive hemodynamic monitoring system in critical care and perioperative settings. Its ability to provide continuous cardiac output monitoring without manual calibration makes it clinically useful for early detection of hemodynamic deterioration. Additionally, integration with VolumeView transpulmonary thermodilution provides advanced parameters such as GEDV and EVLW, which support assessment of preload and pulmonary fluid status.

Goal-directed therapy guided by dynamic parameters such as SVV has been associated with improved hemodynamic optimization in high-risk patients (Cecconi et al., 2014; Michard & Teboul, 2002). Compared with pulmonary artery catheterization, FloTrac reduces invasiveness while still providing clinically relevant hemodynamic data for bedside decision-making. However, clinicians must recognize limitations, particularly reduced accuracy in spontaneously breathing patients and those with arrhythmias or poor waveform quality.

Advantages of FloTrac Monitoring

- Minimally invasive (arterial line only)
- Continuous real-time CO monitoring
- Helps guide fluid therapy and vasopressors
- Useful for goal-directed therapy
- Reduces need for pulmonary artery catheterization

Limitations of FloTrac

- Accuracy reduced in:
  - Severe arrhythmias (AF)
  - Aortic regurgitation
  - Severe vasoplegia
  - Intra-aortic balloon pump
  - Extreme vasoconstriction
- SVV unreliable in spontaneous breathing
- Requires high-quality arterial waveform
- Must be interpreted with clinical findings

CONCLUSION

FloTrac is a minimally invasive hemodynamic monitoring platform that provides continuous and intermittent measurements. By analyzing arterial pressure waveform and using transpulmonary thermodilution with VolumeView, FloTrac supports evaluation of cardiac output, preload, afterload, fluid responsiveness, and lung water status. It plays a valuable role in guiding hemodynamic management in critically ill and high-risk surgical patients.

REFERENCES

Cecconi, M., Corredor, C., Arulkumaran, N., Abuella, G., Ball, J., Grounds, R. M., & Hamilton, M. (2014). Clinical review: Goal-directed therapy—What is the evidence in surgical patients? Critical Care, 17(2), 209.

Evans, L., Rhodes, A., Alhazzani, W., Antonelli, M., Coopersmith, C. M., French, C., Machado, F. R., McIntyre, L., Ostermann, M., Prescott, H. C., Schorr, C., Simpson, S., Wiersinga, W. J., & Levy, M. M. (2021). Surviving Sepsis Campaign: International guidelines for management of sepsis and septic shock 2021. Intensive Care Medicine, 47(11), 1181–1247.

Funk, D. J., Jacobsohn, E., & Kumar, A. (2020). The role of venous return in critical illness and shock—Part I: Physiology. Critical Care Medicine, 48(12), 1824–1830.

Funk, D. J., Jacobsohn, E., & Kumar, A. (2020). The role of venous return in critical illness and shock—Part II: Clinical applications. Critical Care Medicine, 48(12), 1831–1838.

Kulkarni, A. P., Govil, D., Samavedam, S., Srinivasan, S., Ramasubban, S., Venkataraman, R., & Indian Society of Critical Care Medicine (ISCCM) Expert Committee. (2022). ISCCM guidelines for hemodynamic monitoring in the critically ill. Indian Journal of Critical Care Medicine, 26(Suppl 2), S66–S76.

Marino, P. L. (2014). The ICU book (4th ed.). Wolters Kluwer.

Michard, F., & Teboul, J. L. (2002). Predicting fluid responsiveness in ICU patients: A critical analysis of the evidence. Chest, 121(6), 2000–2008.

Monnet, X., & Teboul, J. L. (2020). Assessment of fluid responsiveness: Recent advances. Current Opinion in Critical Care, 26(3), 237–244.

Oh, C., Lee, S., Oh, P., Chung, W., Ko, Y., Yoon, S.-H., & Hong, B. (2022). Comparison between fourth-generation FloTrac/Vigileo system and continuous thermodilution technique for cardiac output estimation after time adjustment. Journal of Clinical Medicine, 11(20), 6093.

Saugel, B., Kouz, K., Meidert, A. S., Schulte-Uentrop, L., & Romagnoli, S. (2020). How to measure blood pressure using an arterial catheter: A systematic 5-step approach. Critical Care, 24, 172.

Vincent, J. L., & Rhodes, A. (2010). Hemodynamic monitoring in the critically ill. Critical Care, 14(2), 1–7.