

# Evaluation of the Vortran Automatic Resuscitator and the Vortran Airway Pressure Monitor in the MRI Environment

A. Berthiaume, Dave Swift RRT

**Introduction:** The magnetic resonance imaging (MRI, 3 Tesla strength) scanner creates a unique electromagnetic environment that allows high fidelity images of patients. With critically ill patients requiring mechanical ventilation, this environment produces some unique challenges in management of ventilation and monitoring of ventilation. Currently, there are a limited number of ventilatory devices that can provide mechanical ventilation in the MRI environment.

**Methods:** To determine if the Vortran Automatic Resuscitator (VAR Plus model) can be safely utilized in the MRI environment. To evaluate, if the Vortran Airway Pressure Monitor (VAPM) can deliver accurate monitoring capability within the MRI environment. The VAR-Plus performance was verified in a bench top setting, within the MRI core (with and without extension lines) and outside of the MRI core (with and without extension lines). The VAPM was used in parallel to verify the VAR-plus performance.

**Results:** The VAR-plus consistently delivered the RATE (within one bpm) and pressure set using a static lung compliance & resistance model. The VAPM unit consistently monitored the set rate. However the unit's ability to monitor the inspiratory time was limited by its design characteristics of only displaying the inspiratory time by rounding up at the 0.05 mark (ex. Ti of 0.56 displays as 0.6 and 0.45 displays as 0.4). The VAPM (Vortran Airway Pressure Monitor) is not designed to be used within the immediate magnetic field of the MRI machine. The magnetic field interferes with its operation and the authors recommend that it not be used within that magnetic field – it does provide effective remote monitoring capability for the VAR-plus.

**Conclusion:** The VAR-plus can effectively function, according to established performance characteristics, within the MRI environment. The unit is not impacted by the electromagnetic field of the MRI scanner. The VAPM provides an effective remote monitor for ventilation within the MRI environment (outside of the magnetic field) for adult and pediatric populations not requiring very low inspiratory times.

**Proposal:** Verify the VAR (Vortran Automatic Resuscitator) performance under the following conditions:

- reaction to MRI while in the core (no extension line)
- reaction to MRI while in core (with extension line)
- reaction to MRI while just outside of core (with extension)
- reaction to MRI while just outside of core (without extension)

Verify the AMP (airway pressure monitor) performance, used with the VAR, under the following conditions:

- pressure accuracy before and after MRI exposure
- reaction to MRI while VAR in the core (no extension line)
- reaction to MRI while VAR in core (with extension line)
- reaction to MRI while VAR just outside of core (with extension)
- reaction to MRI while VAR just outside of core (without extension)

**Evaluators:** Alain Berthiaume, MRI Charge Technologist, Ottawa Hospital; Dave Swift RRT, Campus Coordinator & Charge Respiratory Therapist Ottawa Hospital.

**Equipment:** VAR-plus (VAR plus extension kit) product PCE 5012 & PTE 5002; VORTRAN TEST LUNG model VTL-3600; Vortran Airway Pressure Monitor -3800/pediatric model IP31; MRI: Siemens TIM TRIO, software version V17.3 tesla magnet, TQ-engine (45mT/m@200T/m/s); Draeger C500 Infinity

**Manometer:** Baumanometer BP Manometer with noncompliant tubing (W.A. Baum Co Inc, Coplague, NY, USA).

## Verification of the Vortran Airway Pressure Monitor 3800/pediatric model IP31

Bench Top Test: Using an in-line manometer & the C500 ventilator as the controller the displayed data was compared (ventilator, manometer vs VAPM)

Parameter	C500 ventilator	Manometer	VAPM (6 inch extension line)
RATE	20	---	19
	24	---	23
	30		29
	40		39
	50		50
	60		59 high rate alarm
PEEP	3 cm H2O	2.1 mmHg (2.85 cm H2O)	3 cm H2O
	5 cm H2O	3.7 mmHg (5.03 cm H2O)	5 cm H2O
	7.5 cm H2O	5.3 mmHg (7.20 cm H2O)	7 cm H2O
	10 cm H2O	7.4mm Hg (10.06 cm H2O)	10 cm H2O
Inspiratory Time (Ti seconds)			
	0.3 sec	--	0.3 sec
	0.35 sec	--	0.3 sec
	0.40 sec	--	0.4 sec
	0.45 sec	--	0.4 sec
	0.50 sec	--	0.5 sec
	0.56 sec	--	0.6 sec

In operator control room of MRI no performance changes noted using var equipped without extension tubing compared to bench top verification.

**Verification of the Vortran Airway Pressure Monitor 3800/pediatric model IP31 in operator control room of MRI with var equipped with extension tubing**

Parameter	C500 ventilator	VAPM
RATE	20	18
	24	23
	30	29
	40	39
	50	49
	60	58 high ratealarm
PEEP	3 cm H2O	3 cm H2O
	5 cm H2O	5 cm H2O
	7.5 cm H2O	7 cm H2O
	10 cm H2O	10 cm H2O
Inspiratory Time (Ti seconds)		
	0.3 sec	0.3 sec
	0.35 sec	0.3 sec
	0.40 sec	0.4 sec
	0.45 sec	0.4 sec
	0.50 sec	0.5 sec
	0.56 sec	0.6 sec

**Conclusion**

The Var-plus functions within its designed/specified parameters within the MRI environment. The VAR-plus is a pneumatically powered, continuous flow, pressure cycled, expiratory time limited automatic resuscitator that can provide effective ventilation to a patient within the MRI. As with all pressure cycled devices, changes in lung compliance and resistance can alter the rate and delivered lung volumes. For patient who may undergo dynamic changes in their resistance and compliance the use of the VAPM is essential.

The VAPM is a small, portable monitoring device that displays the inspiratory time, respiratory rate, inspiratory pressure and intrinsic peep on a continuous basis. It provides a high pressure, high rate, and fail to cycle alarms in either an adult or pediatric configuration. The VAPM is not designed to function within the established gauze field and the authors recommend that the optional extension line be used when used within the MRI environment.

**Vortran Automatic Resuscitator – Performance verification (Outside of MRI core)**

Parameter	Set value*	Bench test		
(non-MRI environment)	MRI with extension line	MRI without extension line		
RATE	10 bpm	10 bpm	9 bpm	10 bpm
	12	12	11	12
	20	20	19	20
	30	30	29	29
	40	40	39	40
	50	50	48	49
	60	60	58	59

**Vortran Automatic Resuscitator – Performance verification (Inside of MRI core)**

Note: the VTL-3600 test lungs contained steel screws as part of its assembly and it was effected by the magnetic core and required support to complete the test.

Parameter	Set value*	Bench test		
(non-MRI environment)	MRI with extension line	MRI without extension line		
RATE	10 bpm	10 bpm	9 bpm	10 bpm
	12	12	11	12
	20	20	19	20
	30	30	28	29
	40	40	38	40
	50	50	47	49
	60	60	59	59

\*set value set prior to entry to MRI, unit set & then disconnected from gas source and reconnected in MRI.  
50psi direct connection, no flowmeter used.