Title: PULMONARY AND SYSTEMIC HEMODYNAMIC RESPONSES TO KETAMINE IN INFANTS WITH NORMAL AND ELEVATED PULMONARY VASCULAR RESISTANCE

Authors: P. R. Hickey, M.D., D. D. Hansen, M.D., and G. M. Cramolini, M.D.

Affiliation: Department of Anesthesia, Harvard Medical School; The Children's Hospital, 300 Longwood Avenue, Boston, Massachusetts 02115

Introduction. Ketamine putatively causes increases in pulmonary vascular resistance (PVR) in adults. Clinical experience using ketamine for induction of anesthesia in children with cyanotic heart diseases contradicts this contention. Furthermore, the studies documenting increased PVR in adults have used nonintubated patients breathing spontaneously despite the known effects of ketamine on airway maintenance and respiration;[1] the effect of ketamine on PVR thus may be secondary to effects on ventilation. We therefore studied the pulmonary and systemic hemodynamic responses to ketamine in infants following repair of their congenital heart diseases, after institutional clinical research committee approval.

Methods. We studied 14 infants (mean age 13 m, weight 7.3 kg) one day after operation. They were awake and ready for extubation after sedation had been withheld for at least 4 hours. Baseline heart rate, arterial blood gases (ABGs), systemic and pulmonary arterial pressures, left and right atrial pressures, and thermodilution cardiac outputs were obtained with the infants quiet but responsive while still intubated and breathing spontaneously (FiO_2 0.3-0.4, IMV 4 breaths/min). Repeat measurements were obtained 3-5 minutes and 13-15 minutes after ketamine (2 mg/kg iv) and ABGs were repeated 5-7 minutes. All patients were extubated within an hour after ketamine administration.

Results. All patients became unresponsive 2-3 minutes after ketamine and generally were responsive again by 10 minutes. Table 1 shows hemodynamic results for subgroups with normal (1.5) and elevated (5.6) pulmonary vascular resistance index (PVRI). ABGs did not change significantly after ketamine for either group. No significant change in heart rate, cardiac index (CI), or PVRI occurred with ketamine in the whole group or in the subgroups. Only systemic vascular resistance index (SVRI) changed significantly, decreasing minimally, and only for the whole group of infants.

Discussion. Recent studies in young animals have shown decreases in PVRI with ketamine[2,3] and that sedation with benzodiazepines and droperidol attenuates the acute responses to ketamine in both young and old patients.[4-6] Unchanged pulmonary arterial pressure after ketamine in children premedicated with droperidol has been reported in one anecdotal study, but PVR was not measured in this report.[5]

Infants in our study whose airways were maintained by endotracheal tubes and who were ventilated at least minimally showed no increase in PVR after ketamine regardless of their baseline PVR. While this might be attributed partly to sedation, droperidol was given in none, valium in less than half 6 hours before, and only morphine in most children up to 4 hours before the study. Although mildly sedated, our infants were responsive and ready for extubation.

Although minimal increases in heart rate occurred in our study, they were not significant, nor did increases in mean arterial pressure occur. This suggests that the increases in these parameters reported in other studies also may be due in part to the loss of airway, transient hypoventilation, and hypoxia reported after ketamine.[1] Cardiac index was well maintained in our study. A recent study of congenital heart patients also has found an unchanged ejection fraction after ketamine; this same study also suggests there was no change in pulmonary arterial pressure with ketamine.[7]

We conclude that pulmonary vascular resistance is not changed by ketamine in infants with either normal or elevated pulmonary vascular resistance as long as airway and ventilation are maintained.

References.

1. Zsigmond EK, Matsuki A, Kothary SP, et al: Arterial hypoxemia caused by intravenous ketamine. Anesth Analg 55:311-314, 1976
2. Hanowell ST, Zwischenberger JB, Siwek LG, et al: The effect of ketamine in the lamb with left to right shunt. Anesthesiology 55:A15, 1981
3. Bodai BI, Harms BA, Nottingham PB, et al: The effect of ketamine on endotoxin induced lung injury. Anesth Analg 62:398-403, 1983
4. White PF: Comparative evaluation of intravenous agents for rapid sequence induction-thiopental, ketamine, and midazolam. Anesthesiology 57:279-284, 1982
5. Gassner S, Cohen M, Aygen E, et al: The effect of ketamine on pulmonary artery pressure. Anaesthesia 29:141-146, 1974
6. Balfors E, Haggmark S, Nyhman H, et al: Droperidol inhibits the effects of intravenous ketamine on central hemodynamics and myocardial oxygen consumption in patients with generalized atherosclerotic disease. Anesth Analg 62:193-197, 1983
7. Bini M., Reves JG, Berry D, et al: Ejection fraction during ketamine anesthesia in congenital heart diseased patients. Anesth Analg 63:186(Abst), 1984

Table 1. Hemodynamic Findings (± SEM) with Normal & Elevated Pulmonary Vascular Resistance

	A=normal PVR (n=7)		B=elevated PVR (n=7)			
Variable	Baseline		3-5 minutes after Ketamine		13-15 minutes after Ketamine	
	A	B	A	B	A	B
HR	118±8	114±6	123±8	113±5	123±8	113±5
MAP	75±3	72±6	72±5	69±6	74±4	67±6
MPAP	13±1	27±3	13±2	29±3	13±2	27±4
CI	3.6±.4	3.4±.3	3.8±.4	3.4±.3	3.6±.4	3.4±.4
SVRI (Wood Units)	19±1	20±1	17±1	18±1	19±2	18±2
PVRI (Wood Units)	1.5±.4	5.6±1.2	1.5±.4	5.8±1.0	1.6±.4	5.5±.9

No statistically significant differences noted compared to control for any variable in either group