

Title: HEMODYNAMIC EFFECTS OF HFPPV AND IPPV DURING ACUTE HEMORRHAGE
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Introduction: Intermittent positive pressure ventilation (IPPV), produces a higher transpulmonary pressure (TPP) than high frequency positive pressure ventilation (HFPPV) and decreases venous return and cardiac output (Q). This study compares the hemodynamic effects of IPPV and HFPPV in the same dog during hemorrhage.

Methods: Twenty dogs (weight 29±2 kg) were induced with pentobarbital (30 mg/kg) and paralyzed with pancuronium. IPPV was delivered (via cuffed endotracheal tubes) at: V_t=450ml, rate=10/min, FIO₂=1, peak airway pressure (PAP) 12±0.5 torr. HFPPV was delivered via a jet ventilation catheter placed in the tracheal tube at: V_t=95ml, rate=100, inspiratory time 0.12 sec and PAP = 3.8±0.6 torr using a Bird Mark II respirator-flow cartridge unit. Measurements included: systemic blood pressure (BP), arterial pH and gas tensions, Q and esophageal pressure (EP). Blood was removed from the femoral artery, stored in heparinized bags and transfused (when needed) into the femoral vein using a dialysis pump. Dogs were divided into 4 equal groups. In group A and B, 700ml blood was removed in 2 min and in C and D in 7 min. In A (after control measurements) bleeding was started, while dogs received IPPV. Ten min after hemorrhage, measurements were repeated. Dogs were switched to HFPPV and 10 min later, all variables measured. Dogs were then transfused. Metabolic acidosis (if any) was corrected. After 1 hour, the experiment was restarted with dogs receiving HFPPV. Three sequences were studied per dog: 1) IPPV to HFPPV 2) HFPPV to IPPV and 3) IPPV to HFPPV. In group B, the protocol was the same but the first sequence was HFPPV to IPPV. In group C, blood-letting was done with dogs receiving IPPV. Q was measured every min. Dogs were transfused and HFPPV instituted. After 1 hour, the test was repeated. In D, the dogs were bled while on HFPPV and later switched to IPPV.

Results: In all dogs EP was 8.2± 2 torr during IPPV and 3.4± 1 torr during HFPPV. In groups A and B, during both ventilatory sequences Q and BP were higher during hemorrhage when HFPPV was used (table). Systemic pressure showed baseline variability in the course of hemorrhage only during IPPV (Fig 1). Systolic and diastolic pressures increased 10±3 torr and 6±2 torr respectively with IPPV inspiration over post-expiratory values. In groups C and D, BP and Q were similar at the onset and until 200 ml hemorrhage (Fig 2). However with continued bleeding, Q and BP were higher with HFPPV than with IPPV.

Discussion: The data show that in rapidly developing hypovolemia HFPPV improves Q and BP (possibly due to lower TPP). Higher airway pressure (or TPP) impairs Q during hemorrhage. The high TPP of IPPV also produces baseline variability of arterial pressure (Fig 1). The high TPP forces blood from the lungs into the left heart augmenting left heart filling, Q and BP. Even the augmented pressure was 20% lower than HFPPV values during bleeding episodes. HFPPV enabled group C and D dogs to tolerate gradual blood loss better. Q and BP were higher with HFPPV when blood

volume deficit exceeded 10% (200 ml). The differences between the two modes were more striking at 35% deficit (Q and BP 16% higher with HFPPV, Fig 2). At smaller deficit, the differences were not significant because TPP may only minimally decrease venous return when blood volume is normal or slightly reduced.

References:

1. Ramanathan et al: Anesthesiology 55:A 352, 1981
2. Morgan BC, et al: Anesthesiology 30:297-305, 1969

TABLE
HEMORRHAGE 700 ml

Variable	Control	IPPV	HFPPV	HFPPV	IPPV
		(Group A)		(Group B)	
Q (l/min)	5.7 (0.6)	1.7 (0.6)	2.3 (0.5)	2.4 (0.7)	1.6 (0.7)
BP (s) torr	168 (25)	98 (39)	128 (25)	132 (20)	89 (40)
BP (d) torr	119 (28)	58 (31)	73 (31)	70 (38)	62 (30)
BP (mean) torr	134 (25)	78 (25)	95 (25)	91 (20)	71 (20)
PaO ₂ torr	450 (80)	420 (95)	431 (100)	428 (80)	418 (90)
PaCO ₂ torr	34 (6)	31 (7)	34 (8)	34 (8)	32 (8)
pH	7.5 (0.04)	7.4 (0.02)	7.43 (0.02)	7.42 (0.03)	7.4 (0.0)

Statistics: Arterial pH and gas tensions were not significantly different between modes in groups A and B. All other parameters differed at p<0.01 except Q which differed at p<0.05. Figures in parenthesis = ± 1S.

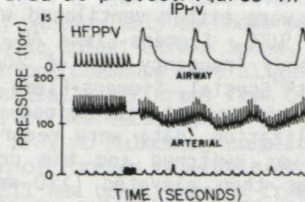


FIG. 1

FIG. 2

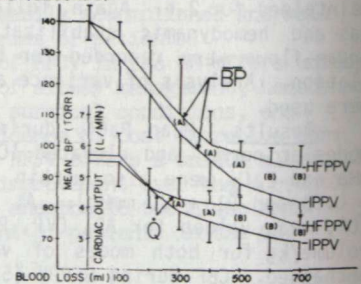


Fig 1: Arterial BP rises with IPPV inspiration in hypovolemia but is steady with HFPPV (variable baseline)
 Fig 2: Fig in parenthesis in abscissa = % blood volume removed. Q and BP were higher with HFPPV at losses higher than 10%. A=p<0.05, B=p<0.01