Title: EFFECTS OF AN ACUTE INCREASE IN [Ca^{++}] ON PULMONARY VASCULATURE

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Introduction. We have shown previously that an acute increase in plasma ionized calcium concentrations (Ca^{++}) following bolus injection of 5 mg/kg calcium chloride ($CaCl_2$) causes predominantly an elevation in systemic arterial pressure via an increase in resistance vessel tone, with little change in cardiac output.[1,2] $CaCl_2$ is used commonly during operation to support hemodynamic function. This occurs frequently in patients with pulmonary hypertension. Since the acute effect of an increased calcium concentration on pulmonary vascular tone in the human has not been clarified, we have subjected the problem to study during operation.

Methods. Thirty-nine adult patients were studied immediately following cardiopulmonary bypass for coronary artery revascularization and/or valve replacement. The patients were divided into two groups according to their mean pulmonary arterial pressure (PAP). Group I (n = 23) included patients with PAP less than 25 torr and group II (n = 16) included patients with PAP greater than 25 torr. Hemodynamic evaluation was performed before and after the administration of a single bolus injection of 5 mg/kg $CaCl_2$ intravenously. Hemodynamic variables, measured and calculated, included heart rate (HR), systemic arterial pressure (AP), pulmonary artery pressure (PAP), left and right ventricle filling pressures (LVFP, RVFP), cardiac output and index (CO, CI), stroke volume and index (SV, SI), systemic and pulmonary vascular resistance (SVR, PVR), left and right ventricular stroke work index (LVSWI, RVSWI). The data were analyzed using the correlated and uncorrelated Student t-test.

Results. Following $CaCl_2$ administration, HR remained unchanged in both groups (Table 1). Mean AP increased significantly by 8% ($P < 0.01$) in group I. Mean PAP increased significantly by 14% ($P < 0.01$) in group II only. LVFP decreased significantly in both groups (23% and 14%) while RVFP increased significantly by 20% ($P < 0.01$) in group II. Cardiac index and stroke index remained unchanged. Pulmonary vascular resistance increased significantly in group II by 45% ($P < 0.001$). RVSWI increased also in group II by 10% ($P < 0.05$). Ventricular arrhythmias following $CaCl_2$ administration were seen in four patients with pulmonary hypertension (group II).

Discussion. Our data indicate that an acute i.v. administration of $CaCl_2$ is associated with an increase in PVR, particularly if pulmonary hypertension is present. Since stroke volume did not change and LVFP decreased, this increase is due to pulmonary vasoconstriction. Similarly, the increase in mean AP appears to be secondary to a rise in SVR. Thus administration of $CaCl_2$ in the presence of pulmonary hypertension and RV failure may exacerbate deterioration of RV function secondary to greater pulmonary vasoconstriction. The overall hemodynamic benefits associated with the acute intraoperative use of calcium may be limited by the effect of this ion on pulmonary vascular tone and associated capability of the RV to adjust to an increased afterload. In the presence of RV hypertrophy and borderline systemic blood pressure, such an increase in "afterload" may result in RV ischemia. The possibility must be entertained that administration of $CaCl_2$ in small quantities may cause arrhythmias secondary to RV ischemia, rather than a direct effect of [Ca^{++}] on the myocardium.

References.

1. Lappas DG, Drop LJ, Buckley MJ, Mundth ED, Laver MB: Hemodynamic response to calcium chloride during coronary artery surgery (Abstr). Surg Forum 26:234-235, 1975

2. Drop LJ, Laver MB, Williams W: Persistent hypocalcemia during low flow states following cardiac surgery (Abstr). Circulation 48 (Suppl 4):IV-99, 1973

TABLE 1

	Group I (n=23)		Group II (n=16)	
	Control	With $CaCl_2$	Control	With $CaCl_2$
HR b/min	78±5	81±4	82±5	83±5
AP torr	76±4	82±5**	75±4	78±4*
PAP torr	18±2	19±1	36±4	41±4**
LVFP torr	13±2	10±1**	17±2	15±2*
RVFP torr	7±1	8±1	10±1	12±1**
CI $l/min/m^2$	2.5±0.2	2.6±0.1	2.5±0.3	2.3±3
SI $ml/min/m^2$	32±3	33±4	30±4	28±3
SVR units	16±2	17±2*	15±2	16±2*
PVR units	1.1±0.3	1.9±0.5*	4.4±0.7	6.5±1***
RVSWI $g \cdot m/m^2$	4.7±0.6	4.9±0.6	10±1	11±1*

mean±SEM; *P<0.05; **P<0.01; ***P<0.001