Title: MODERATE HYPOTENSIVE ANESTHESIA WITH ENFLURANE AND ISOFLURANE - BENEFICIAL FOR THE ISCHEMIC HEART?

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During surgical stimulation volatile anesthetics almost unanimously are considered to have advantageous effects on the O_2-balance of the ischemic myocardium, since they are an effective tool for therapy or prevention of pain-induced tachycardia and/or hypertension. Controversial, however, are their effects on O_2-balance in periods of hypotension due to lack of surgical stimulation. Which is more predominant: the decreased perfusion resulting from the fall in coronary perfusion pressure or the decrease in myocardial oxygen consumption due to the reduction of afterload and contractility? To answer this question, we developed an acute model of coronary stenosis in pigs, that permitted us to perform nearly atraumatic measurements of regional O_2-delivery and regional tissue oxygenation. This model was based on creating a degree of stenosis, where a pacemaker induced increase of the heart rate by 40/min causes a fall of myocardial tissue pO_2 ($p_t O_2$) to or near zero mmHg, concomitant with a marked increase in net lactate production. Using this model the influence of a mild, clinically often observed, Enflurane (ENF) or Isoflurane (ISO) induced hypotension on O_2 delivery and $p_t O_2$ of the poststenotic and the normal myocardium was studied.

Methods: Sternotomy and pericardiotomy were performed in 14 pigs (m.b.w. = 30 kg) under neurolept anesthesia. To create a stenosis a highly flexible teflon-coated copperwire was placed around the left-anterior descending coronary artery (LAD) 2-3 cm from its origin. Catheters were inserted into the left atrium (injection of 15um-microspheres for determination of regional blood flow) and the great cardiac vein to sample blood from the area predominantly supplied by the LAD). For continuous monitoring of $p_t O_2$ a multiwire surface electrode (MSE) was placed on the myocardium supplied by the LAD and a second MSE on the area supplied by the left circumflex artery (CX). Following the baseline recording the LAD was constricted until $p_t O_2$ in the LAD-area was reduced to about 50%. Following measurements under this degree of stenosis, ISO (A, n=7) or ENF (B, n=7) were administered to reach a MAP of 75 mmHg for a period of 30 min. Then all measurements were repeated as well as 30 min after elimination of both volatile anesthetics.

Statistics: mean ± SD, Friedman's rank analysis of variance; Wilcoxon-Mann-Whitney were used as appropriate.

Results: Baseline conditions: Mean $p_t O_2$-values were 45 mmHG (range: 36-62) in both the LAD-area ($p_t O_{2LAD}$) and in the CX-area ($p_t O_{2CX}$). Arterial-venous oxygen difference values ($AVDO_2$) in the LAD-area were 9.6 + 1.7 (A) and 9.0 ± 1.2 vol% (B). Arterio-venous lactate differences amounted to +0.4 ± 0.3 (A) and +0.3 ± 0.1 mMol/l (B).

Stenosis: The LAD was constricted until $p_t O_2$-values were 21 mmHg (range: 12 - 34) in both groups, while $p_t O_{2CX}$ remained unchanged at 46 mmHg (range: 35 - 57). The decrease of $p_t O_{2LAD}$ was associated with increases of $AVDO_2$ to 11.2 ± 1.4 (A) and 10.0 ± 2.0 vol% (B) and of net lactate production (A: AVDL = - 0.4 ± 0.4; B: AVDL = -0.6 ± 0.7 mMol/l). Under this degree of stenosis regional blood flow values in the LAD-area (Q_{LAD}) were 81 ± 18 (A) and 86 ± 16 ml/100g x min, 20% less than in the CX-area, where 101 ± 25 (A) and 105 ± 19 ml/100g x min (B) were measured. Subendocardial blood flow values were lower than subepicardial blood flow values (I/O ratio 0.8) in the LAD-area, but not in the CX-area (I/O ratio 1.1).

Stenosis plus ENF or ISO: Endexpiratory concentrations of 0.8 ± 0.2 ISO and 0.9 ± 0.3 ENF were necessary to reduce MAP values from 101 ± 13 to 76 ± 3 mmHg (A) and from 92 ± 10 to 74 ± 3 mmHg (B). No changes in left ventricular enddiastolic pressure (LVEDP) and heart rate (about 95/min in both groups) were observed, the significant decrease in MAP and cardiac output (CO) caused a significant fall of left ventricular stroke work/sec (LVSW/s) - a parameter considered to reflect myocardial oxygen consumption - by 30% in both groups. Q_{CX} decreased by 20% to 81 ± 18 (A) and 86 ± 15 ml/100 g x min (B). Q_{LAD} fell by 30% to 56 ± 18 (A) and 54 ± 10 ml/100 g x min (B). Furthermore there was a tendency towards a further decrease of the I/O ratio in the LAD area. $p_t O_{2LAD}$-values decreased significantly to 9 mmHg (range: 0-27) under ISO and to 13 mmHG (range: 0-33) under ENF. $p_t O_{2CX}$ remained unchanged in both groups. Despite the fall in $p_t O_{2LAD}$ the $AVDO_2$ of the LAD-area was unchanged in both groups, whereas net lactate production increased in both groups (A: AVDL = -1.0 ± 0.7; B:AVDL = -0.8 ± 0.5).

Discontinuation of ISO and ENF: 30 min after discontinuation of volatile anesthetics in both groups MAP, CO, LVSW/s, $AVDO_2$, net lactate production and $p_t O_{2LAD}$-values returned to levels before application of volatile anesthetics.

Conclusion: A moderate but clinically not unusual decrease of MAP by ENF or ISO leads to a deterioriation of tissue oxygenation in poststenotic areas inspite of a reduction of myocardial O_2-consumption. Thus, a slight to moderate hypotensive anesthesia with ENF (1) or ISO (2,3) does not have beneficial effects on the poststenotic myocardium as postulated by some authors (1,2,3,).

References :

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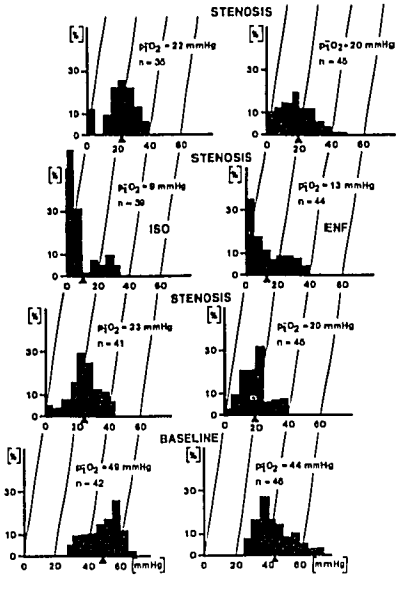

Fig.: Tissue pO_2 of the myocardium supplied by the LAD ($p_t O_{2LAD}$) given as pO_2-distribution curves. Creation of the stenosis led to a leftward shift of $p_t O_{2LAD}$. ISO (left) and ENF (right) caused a further decrease of $p_t O_2$. After discontinuation of ISO and ENF $p_t O_{2LAD}$ returned to levels before application of both volatile anesthetics.