Gatto

…cosa sappiamo

Gatto-dinamica

Principi base

- Ossigenazione Tissutale = Perfusione x Contenuto O2
- In Anestesia Generale l'ossigeno lo diamo noi... e la Perfusione??
- La Perfusione è correlata alla Pressione
- Mancata Perfusione d'organo porta a mancata Ossigenazione d'organo

Pressione Arteriosa (BP)

- BP= CO x TPR
- CO= Cardiac Output (Portata Cardiaca)
- SV= Stroke Volume (Gittata)
- CO= Frequenza cardiaca x SV

- TPR= Resistenze periferiche totali

- Precarico: distensione delle fibre muscolari cardiache a fine diastole, determinato dal volume di sangue che riempie il ventricolo

- Postcarico: resistenze contro le quali il ventricolo deve pompare

TPR

- Il fattore che influenza maggiormente le TPR è il diametro del letto vasale
- Vasocostrizione
- Vasodilatazione
- Viscosità del sangue (ematocrito)

Pressione arteriosa sistolica, diastolica e media

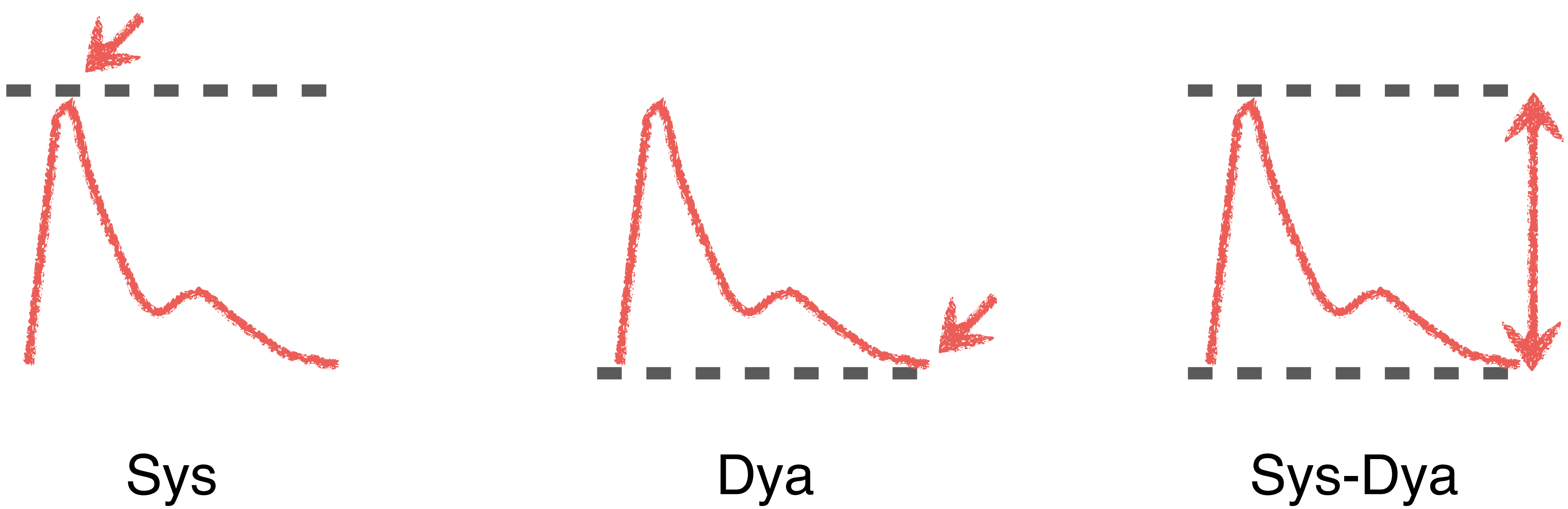
- Sistolica (SAP): Valore pressorio massimo raggiunto durante una sistole a livello arterioso espresso in mmHg
- Diastolica (DAP): Valore pressorio minimo arterioso (cuore in diastole) espresso in mmHg
- Media (MAP): Valore medio di pressione arteriosa durante tutta la fase del polso espresso in mmHg

Significato Clinico

- Sistolica: indice indiretto di contrattilità
- Diastolica: correla con la frequenza e le TPR
- Media: PERFUSIONE

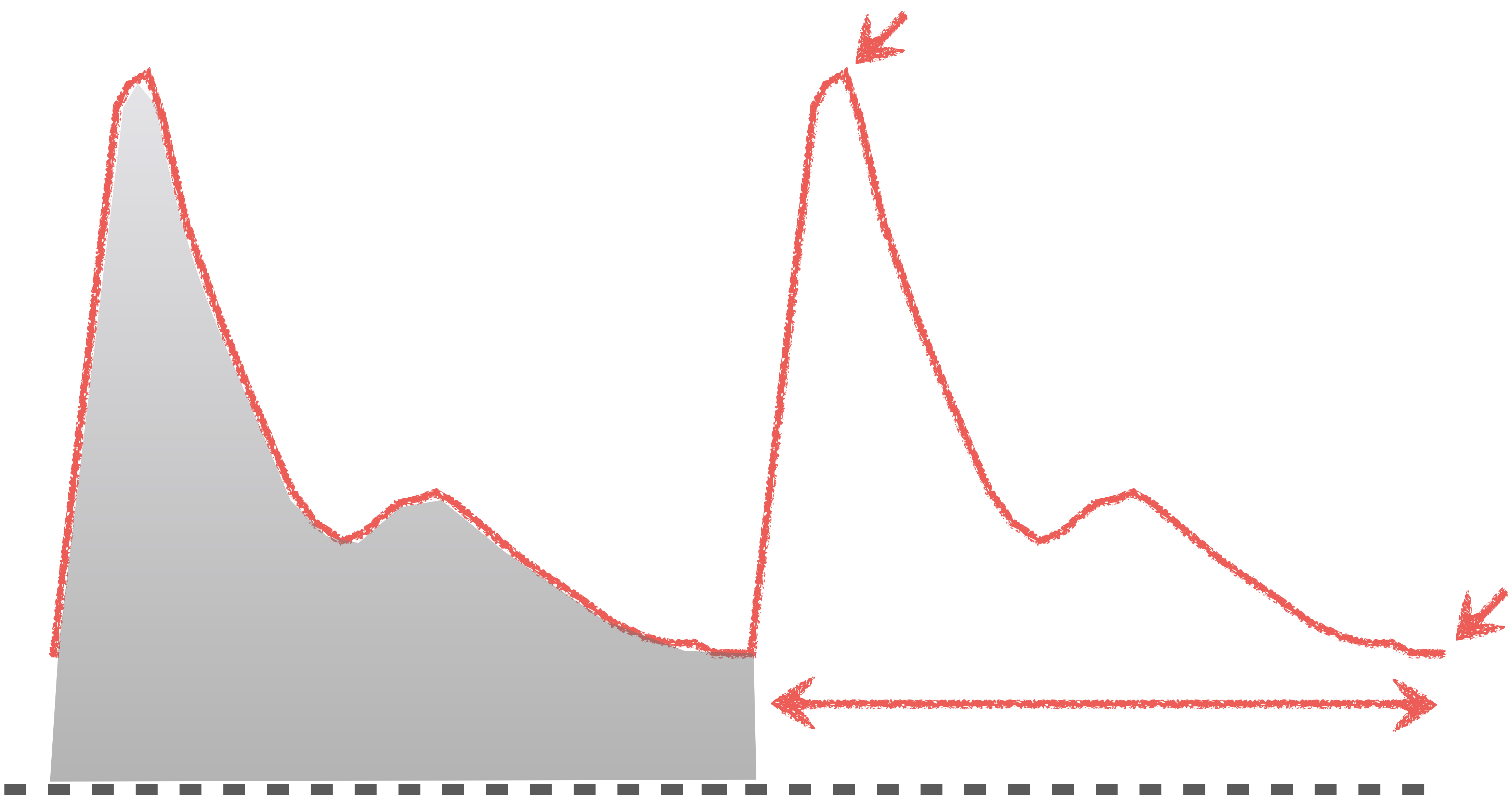
A occhio nudo

- Sistolica (Sys)
- Diastolica (Dya)
- Differenziale Sistolo-Diastolico (Sys-Dya)



Media (MAP)

- Sys
- Dya
- AUC
- Tempo ciclo Cardiaco (Fc)



Media (MAP)

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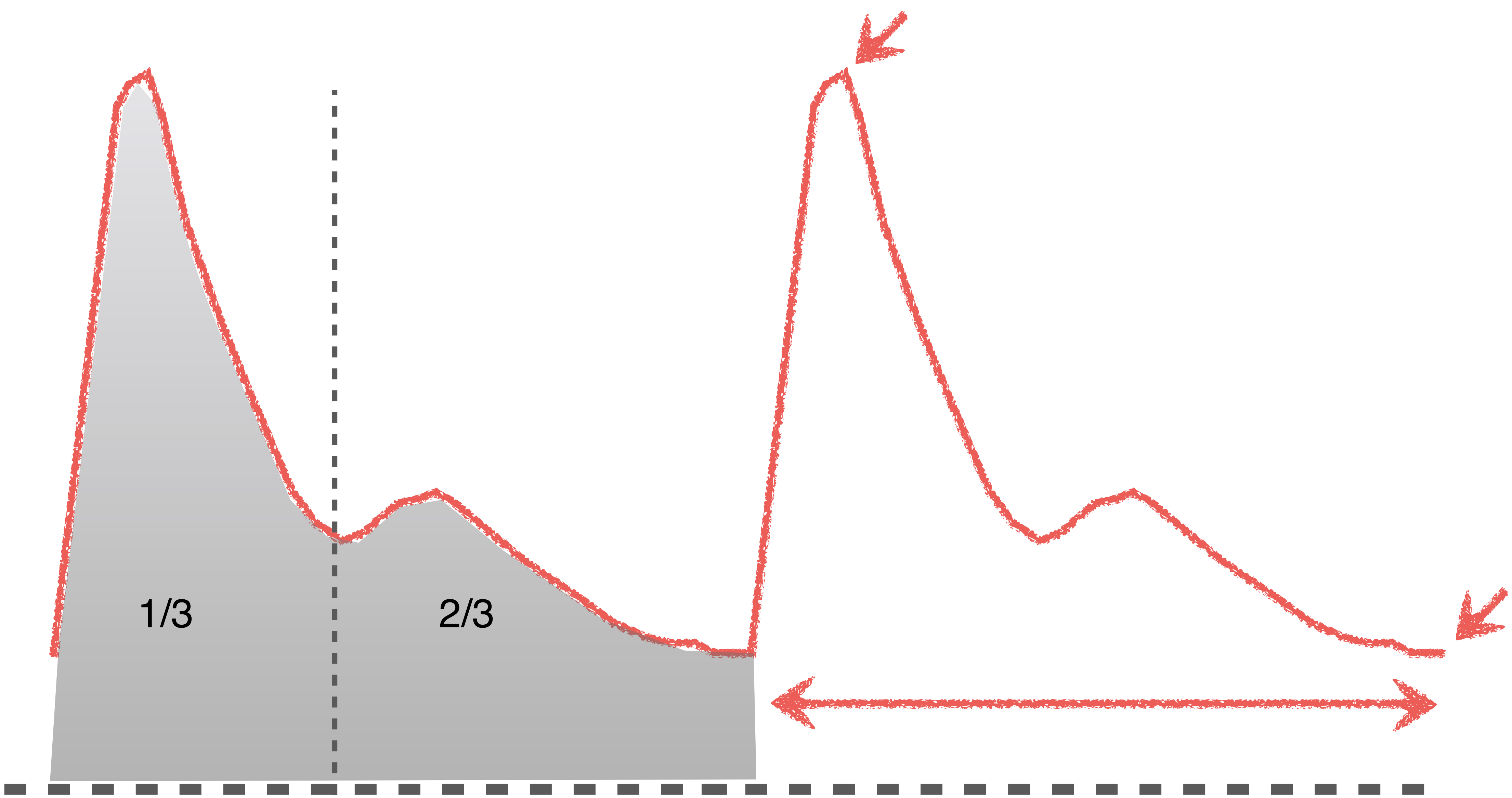
- Dya
- AUC
- Tempo ciclo Cardiaco (Fc)



Media (MAP)

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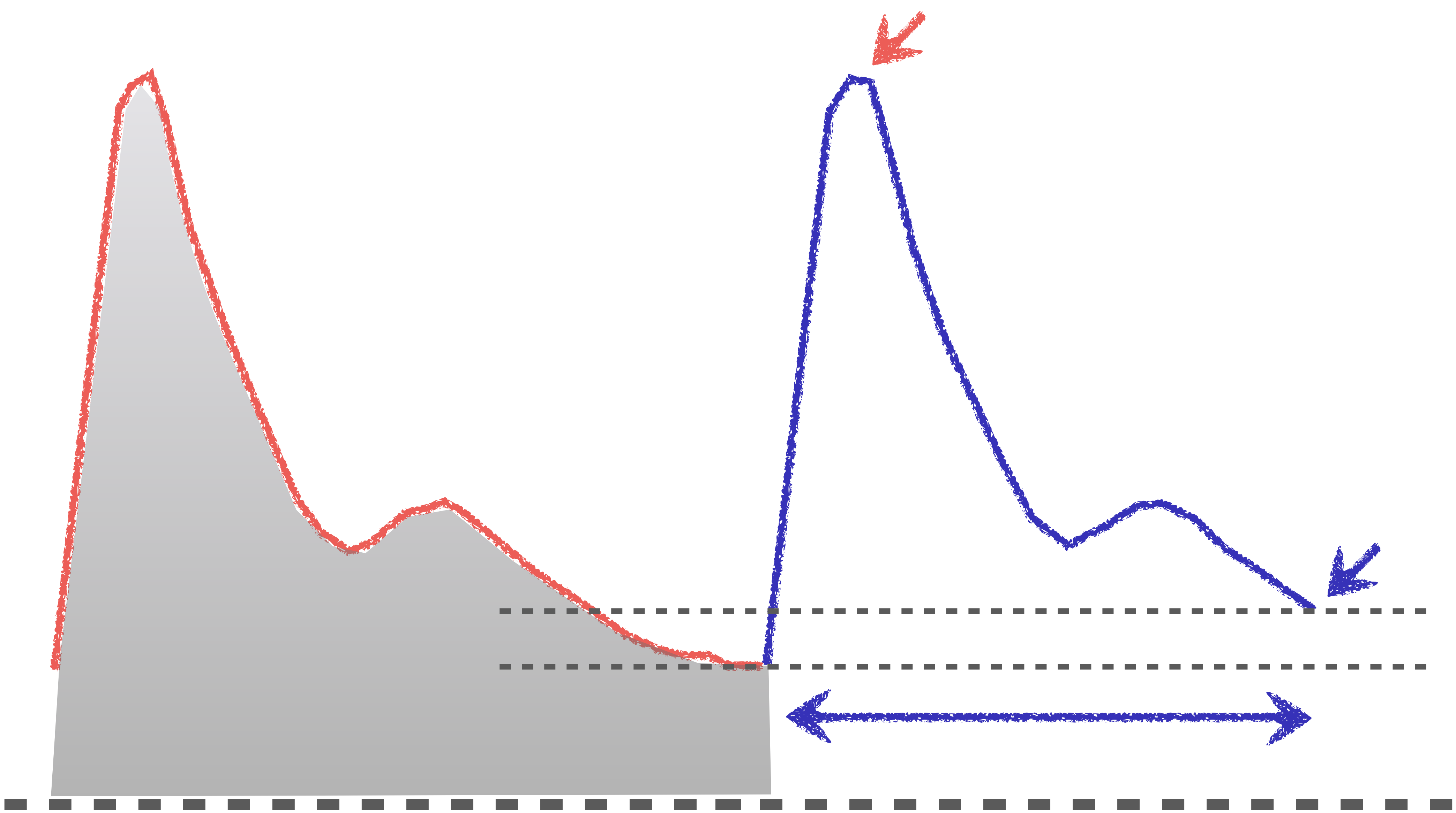


Doppler

- Sfrutta l'effetto doppler (effetto sirena dell'ambulanza)
- Il rientro del sangue nell'arteria occlusa dal manicotto si riflette con un cambio di frequenza dovuto al movimento dei globuli rossi

Fattori che influenzano la misurazione

- Angolo del trasduttore
- Pressione sul trasduttore
- La velocità di sgonfiamento della cuffia
- La misura della cuffia
- L’orecchio e l’attenzione dell’operatore

Doppler in pillole

- Posizionamento: faccia palmare regione metacarpale (metatarsale plantare e dorsale)
- Scelta cuffia: 40% circonferenza arto
- Artefatti tutti Operatore dipendenti
- Accuratezza: buona correlazione con IBP sulla sistolica
- Costo moderato, facile da usare, di vitale importanza nel gatto
- Principale pecca: rileva solo la sistolica

Oscillometrico (NIBP)

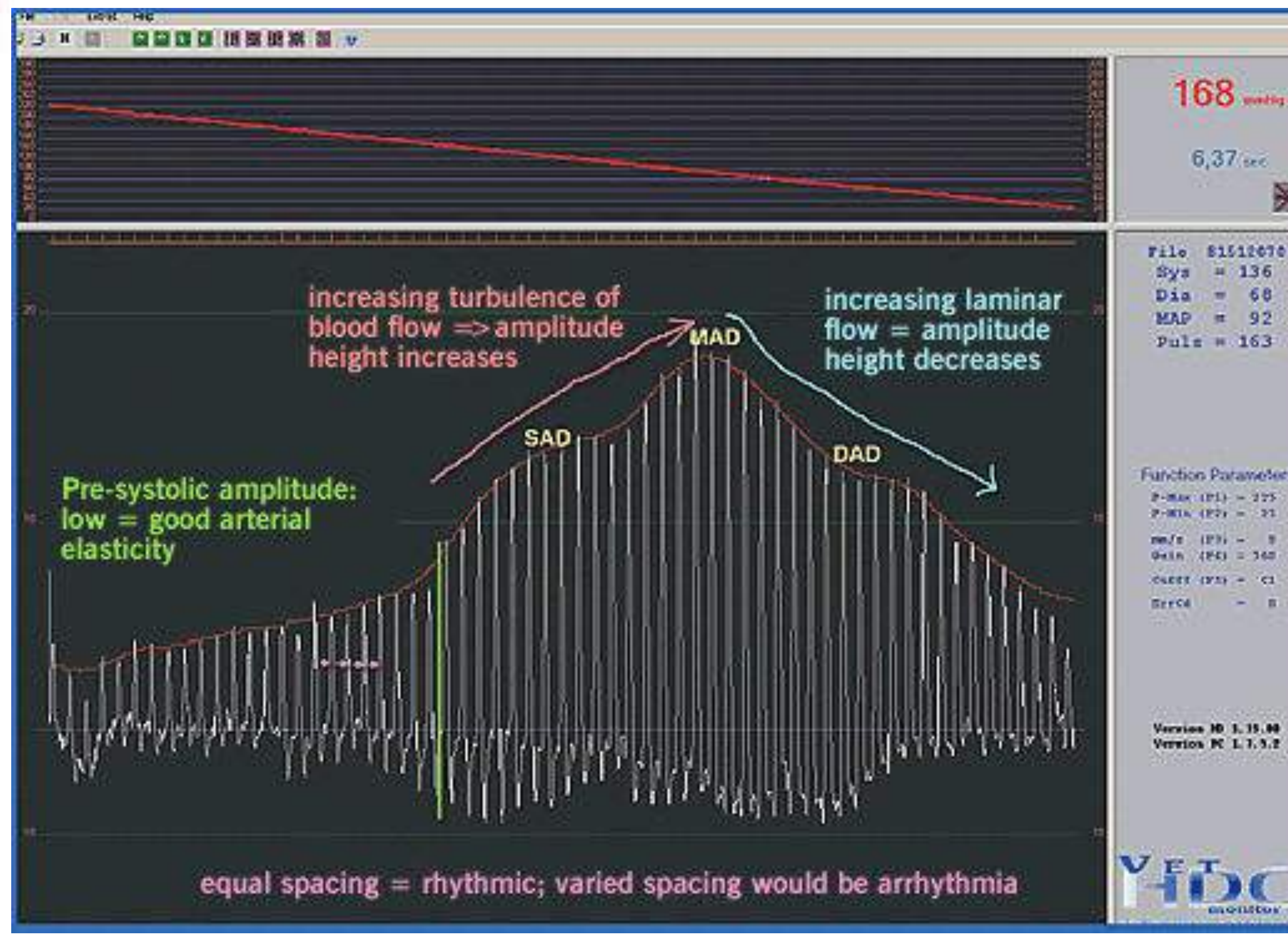
- Rileva sulla cuffia le vibrazioni pulsatili della parete dell’arteria

- Sfrutta l’effetto korotkoff (ricomparsa oscillazioni pulsatili crea pressione di spinta sulla cuffia)

NIBP in pillole

- Posizionamento: zona di proiezione arteria Radiale, Tarsale, Coccigea, ***Safena, Brachiale (gatto) ?***
- Scelta cuffia: 40% circonferenza arto
- Artefatti: micromovimenti, bradicardia, aritmia ventricolare
- Accuratezza: variabile secondo il modello (confrontare con metodo invasivo)
- Sensibilità: dipende dal cut off analisi ampiezza segnale
- Facilità d’uso: ottima (automatico)
- Tipo di rilievo: SAP DAP (MAP Calcolata)
- Costi: variabile (inserito in Multiparametrico)

HDO



168
6,37
Sys = 136
Dia = 68
MAP = 92
Puls = 163
Function Parameters
increasing turbulence of blood flow => amplitude height increases
MAD
increasing laminar flow = amplitude height decreases
SAD
DAD
Pre-systolic amplitude: low = good arterial elasticity
equal spacing = rhythmic; varied spacing would be arrhythmia

https://www.youtube.com/watch?v=JQY9xNo58j4

Pressione Arteriosa Invasiva (IBP)

- Canula venosa eparinizzata (20-22 G) cane e ***(22-24G) gatto*** inserita in arteria
- Arteria Tarsale (dorsale del piede), Femorale
- Sacca di fisiologica eparinizzata messa in pressione con spremi sacca (300 mmHg)
- Deflussore dedicato con trasduttore e sistema di flush con collegamento per cavo monitor

Attenzione!!

- Misura catetere venoso e lunghezza deflussore
- Trasduttore altezza cuore
- Arteria o canula cubitata
- Bolle d’aria nel circuito
- Sacca non insufflata
- Misura ago inserito nel tappo perforabile
- Azzeramento

IBP Sempre e comunque

- Gold Standard
- Vantaggi clinici (permette di aver una risposta pronta e tempestiva ad ogni evento ipotensivo o ipertensivo)
- Non solo valore numerico, ma un'onda da analizzare (battito per battito)

Cosa Sappiamo

Veterinary Anaesthesia and Analgesia
Formerly the Journal of Veterinary Anaesthesia

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RESEARCH PAPER

Hemodynamic effects of dexmedetomidine in isoflurane-anesthetized cats

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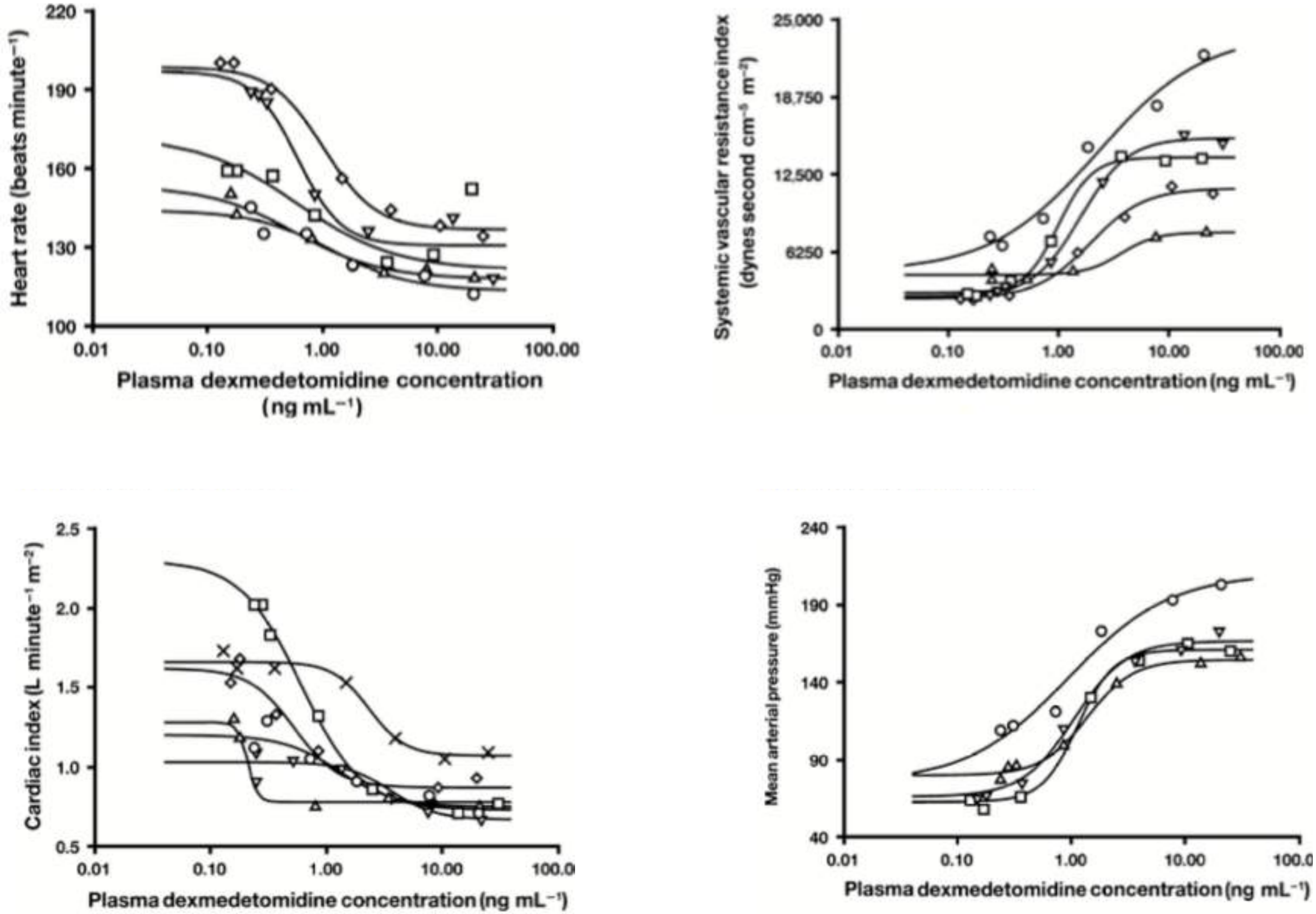
Table 1 Mean ± SD baseline values (i.e. values measured before administration of dexmedetomidine) for the study variables, obtained in six cats

Variable	Mean ± SD	Variable	Mean ± SD
HR	172 ± 21	Hb$\bar{v}$	10.6 ± 1.3
SAP	87 ± 10	Sodium	150 ± 0.5
DAP	54 ± 7	Potassium	3.9 ± 0.4
MAP	67 ± 7	Chloride	124 ± 3
CVP	8 ± 3	Calcium	1.23 ± 0.13
MPAP	18 ± 2	Glucose	123 ± 25
PAOP	12 ± 3	Lactate	1.2 ± 0.1
Temperature	38.4 ± 0.3	CI	1.48 ± 0.43
PCV	27 ± 6	SI	0.52 ± 0.13
TP	5.0 ± 0.5	RPP	14,982 ± 3044
PaO_2	457 ± 55; 61 ± 7	SVRI	3300 ± 653
$PaCO_2$	40.4 ± 3.7; 5.4 ± 0.5	PVRI	345 ± 97
pHa	7.321 ± 0.048	LVSWI	0.387 ± 0.160
Arterial HCO_3^-	19.8 ± 0.7	RVSWI	0.070 ± 0.034
SaO_2	99.8 ± 0.3	CaO_2	16.0 ± 1.6
Arterial Hb	10.9 ± 1.1	$C\bar{v}O_2$	12.0 ± 2.4
$P\bar{v}O_2$	73 ± 21; 9.7 ± 2.8	$\dot{D}O_2$	63.5 ± 17.1
$P\bar{v}CO_2$	46.4 ± 3.9; 6.2 ± 0.5	$\dot{V}O_2$	15.1 ± 3.2
pH$\bar{v}$	7.288 ± 0.044	O_2 extraction	0.25 ± 0.08
Mixed-venous HCO_3^-	21.0 ± 0.9	$P(A\text{-}a)O_2$	216 ± 56; 28.8 ± 7.5
$S\bar{v}O_2$	82.3 ± 6.6	$\dot{Q}_s/\dot{Q}_t$	0.15 ± 0.05



Heart rate (beats minute⁻¹)
220
190
160
130
100
0.01
0.10
1.00
10.00
100.00
Plasma dexmedetomidine concentration (ng mL⁻¹)
Systemic vascular resistance index (dymes second cm⁻⁵ m⁻²)
25,000
18,750
12,500
6250
0
0.01
0.10
1.00
10.00
100.00
Plasma dexmedetomidine concentration (ng mL⁻¹)
Cardiac index (L minute⁻¹ m⁻²)
2.5
2.0
1.5
1.0
0.5
0.01
0.10
1.00
10.00
Plasma dexmedetomidine concentration (ng mL⁻¹)
Mean arterial pressure (mmHg)
240
190
140
90
40
0.01
0.10
1.00
10.00
Plasma dexmedetomidine concentration (ng mL⁻¹)

Table 2 Weighted mean ± SE pharmacodynamic parameters for variables that increased following dexmedetomidine administration

Variable	E_0	EC_{50}	E_{max}	Gamma	*N*
SAP	87 ± 6	1.12 ± 0.09	102 ± 17	1.45 ± 0.42	4
DAP	57 ± 3	1.12 ± 0.10	80 ± 10	1.71 ± 0.37	4
MAP	73 ± 4	1.21 ± 0.09	86 ± 12	1.74 ± 0.37	4
CVP	10 ± 2	0.73 ± 0.60	5 ± 0.4		4
PAP	17 ± 1	1.99 (0.88–6.96)*	8 (7–12)*	1.76 ± 0.28	5
PCV	32 ± 3	1.29 ± 0.38	10 ± 3	3.28 ± 0.47	4
Arterial Hb	9.7 (9.3–12.0)*	1.46 ± 0.72	4.2 ± 0.6	1.31 ± 0.30	5
Mixed-venous Hb	9.9 ± 0.5	1.32 ± 0.54	4.9 ± 0.4	1.25 ± 0.20	5
Glucose	151 ± 23	0.26 ± 0.19	168 ± 28		3
SVRI	3062 ± 457	1.21 ± 0.45	10,770 ± 2577	1.67 ± 0.35	5
PVRI	429 ± 74	1.29 ± 2.03	987 ± 92		3
LVSWI	0.343 ± 0.026	0.61 ± 0.23	0.536 ± 0.060	1.27 ± 1.46	3
CaO_2	14.3 (13.7–17.4)*	1.33 ± 0.59	5.8 ± 0.8	1.44 ± 0.27	5
O_2 extraction	0.26 ± 0.05	0.83 ± 0.03	0.08 ± 0.03	1.63 ± 0.36	3

*Values reported as mean (range) because they were not normally distributed. E_0: effect in the absence of dexmedetomidine (unit of the variable); EC_{50}: plasma dexmedetomidine concentration at which 50% of E_{max} is produced (ng mL^{-1}); E_{max}: maximum possible increase in effect (unit of the variable); Gamma: sigmoidicity factor. Missing gamma values indicate that a simple effect maximum model best fitted the data for that variable. *N* is the number of cats in which the model fitted the data adequately. E_0 values may be different from baseline values (Table 1) because they were estimated by the models. See Table 1 for remainder of key.

Table 3 Weighted mean ± SE pharmacodynamic parameters for variables that decreased following dexmedetomidine administration

Variable	E_0	IC_{50}	I_{max}	Gamma	*N*
HR	165 ± 11	0.75 ± 0.13	47 ± 7	1.34 ± 0.24	5
CI	1.49 ± 0.19	0.45 ± 0.54	0.55 (0.36–1.57)*	2.24 (1.65–10.00)*	6
Mixed-venous pH	7.290 ± 0.018	0.90 ± 0.27	0.080 ± 0.006		3
SvO_2	80.5 (80.4–92.4)*	0.37 ± 0.15	8.1 ± 4.3	1.19 ± 0.82	3

*Values reported as mean (range) because they were not normally distributed. E_0: effect in the absence of dexmedetomidine (unit of the variable); IC_{50}: plasma dexmedetomidine concentration at which 50% of I_{max} is produced (ng mL^{-1}); I_{max}: maximum possible decrease in effect (unit of the variable); Gamma: sigmoidicity factor. The missing gamma value for mixed-venous pH indicates that a simple inhibitory maximum model best fitted the data for that variable. *N* is the number of cats in which the model fitted the data adequately. E_0 values may be different from baseline values (Table 1) because they were estimated by the models. See Table 1 for remainder of key.

Table 4 Median (range) maximum observed change from baseline and maximum observed change indexed to baseline measurements following dexmedetomidine administration for selected variables

Variable	Direction of change	Maximum observed change	Maximum observed change (% baseline measurement)
PAOP	Increase	4 (2–8)	33 (13–86)
PaO_2	Increase	72 (1–129); 10 (0.1–17)	15 (0.2–36)
$PaCO_2$	Increase	2.8 (0–7.5); 0.4 (0–1.0)	7 (0–19)
Arterial pH	Decrease	0.064 (0.047–0.108)	0.9 (0.6–1.5)
Arterial HCO_3^-	Decrease	2.1 (1.7–3.8)	11 (8–18)
$P\bar{v}O_2$	Decrease	11 (0–50); 1 (0–7)	17 (0–44)
$P\bar{v}CO_2$	Increase	10.3 (4–12.4); 1.4 (0.5–1.7)	23 (9–27)
Calcium	Decrease	0.2 (0.09–0.4)	17 (8–27)
RPP	Increase	9478 (1994–16,560)	63 (14–145)
SI	Decrease	0.14 (0.04–0.44)	29 (8–57)
$\dot{Q}s/\dot{Q}t$	Decrease	0.10 (0.05–0.16)	66 (50–73)

Dexmedetomidine decreased heart rate in a concentration-dependent manner. Alpha-2 agonists have been shown to cause decreases in heart rate by increasing baroreceptor responses to increases in blood pressure, decreasing sympathetic tone, and/or increasing parasympathetic tone (Badoer et al. 1983; Harron et al. 1985; Devcic et al. 1994; Xu et al. 1998; Vayssettes-Courchay et al. 2002; Penttila et al. 2004). In this study, the model predicts that, on average, the lowest heart rate observed at

high dexmedetomidine concentration would be approximately 118 beats minute^{-1}, which would be considered mild to moderate bradycardia in anesthetized cats. Cardiac index decreased with increasing plasma dexmedetomidine concentration. This change appears in large part related to the effect on heart rate. However, stroke index also decreased, although the changes could not be modeled. Direct effects of alpha-2 agonists on myocardial contractility are unlikely (Flacke et al. 1990); the decrease in stroke index is most likely related to a combination of increase in afterload, due to the increase in systemic vascular resistance, and decreased sympathetic tone (Bloor et al. 1992). Systemic and pulmonary vascular resistance indices increased due to the effect of alpha-2 agonists on the vascular smooth muscle (Hyman & Kadowitz 1985; Ruffolo 1985; Duka et al. 2000; Talke et al. 2001; Willems et al. 2001; Gornemann et al. 2007, 2009). This vasoconstrictive effect leads to the

concentration, related to the increase in hemoglobin concentration, which prevented oxygen delivery from decreasing in the face of decreased cardiac output. However, it is possible that imbalances between oxygen delivery and consumption occurred at the local level. Indeed, $P\bar{v}O_2$ and SaO_2 decreased, and oxygen extraction ratio increased with increasing plasma dexmedetomidine concentrations, indicating that despite the lack of statistical change in oxygen delivery and consumption, the ratio of delivery to consumption decreased. Venous admixture was lower than baseline at the highest

dexmedetomidine concentration. This is possibly due to the effect of decreased cardiac output on intrapulmonary shunting (Lynch et al. 1979), and contributed to the increase in PaO_2. PCO_2 was higher than baseline at the highest plasma dexmedetomidine concentration in both arterial and mixed-venous blood, indicating that dexmedetomidine, at least when high doses are administered, worsens the respiratory depressant effect of isoflurane. The increase in PCO_2 resulted in a decrease in blood pH. In addition, arterial bicarbonate concentration also decreased, contributing to the decrease in arterial pH. Blood glucose concentration increased with dexmedetomidine administration; this effect is likely due to a combination of an inhibition of insulin secretion by alpha-2 agonists (Angel et al. 1988) and the administration of dextrose in water for cardiac output measurement.

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Cuore

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Resistenze Periferiche

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Cuore

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Resistenze Periferiche

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Perfusione

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Ventilazione

dexmedetomidine concentration. This is possibly due to the effect of decreased cardiac output on intrapulmonary shunting (Lynch et al. 1979), and contributed to the increase in PaO_2. PCO_2 was higher than baseline at the highest plasma dexmedetomidine concentration in both arterial and mixed-veno[illegible]d, indicating that dexmedetomidine, at le[illegible]h doses are administered, worsens the resp[illegible]ant effect of isoflurane. The increase in P[illegible] decrease in blood pH. In addition, arterial [illegible]te concentration also decreased, contributing [illegible] the decrease in arterial pH. Blood glucose concentration increased with dexmedetomidine administration; this effect is likely due to a combination of an inhibition of insulin secretion by alpha-2 agonists (Angel et al. 1988) and the administration of dextrose in water for cardiac output measurement.

In conclusion, in isoflurane-anesthetized cats, dexmedetomidine produces hemodynamic effects in a concentration-dependent manner. These effects are mainly characterized by a decrease in heart rate and cardiac output, and an increase in blood pressure and systemic and pulmonary vascular resistances. At plasma concentrations producing

↓ Frequenza Cardiaca
↓ Portata Cardiaca
↑ Pressione
↑ Resistenze Vascolari

Effects of increasing infusion rates of dopamine, dobutamine, epinephrine, and phenylephrine in healthy anesthetized cats

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Therefore, it would appear that dopamine is likely to be the most useful drug in clinical anesthesia in which the first aim is to increase blood pressure and perfusion. Results of the study reported here indicated that dopamine needed to be titrated to effect because there is variation in individual plasma concentrations. Dobutamine is at least as effective at increasing blood flow, but because it tends to decrease systemic vascular resistance, it is likely to have less effect on blood pressure. This is an important distinction in a clinical setting in which blood pressure is easy to measure and there is no simple method of measuring blood flow. Epinephrine is at least as effective as dopamine but has the negative effects of increasing lactic acid production and increasing base deficit. Phenylephrine is normally used in cases in which it is advantageous to increase blood pressure by vasoconstriction. This may be useful in animals with pronounced systemic vasodilation, such as in visceral inflammation. It may also be used to increase blood pressure in cases in which increases in myocardial contractility may be disadvantageous, such as in hypertrophic cardiomyopathy. None of the infusions used in our study in healthy cats induced serious arrhythmias. Results of our study bore out our original hypothesis, except that phenylephrine, at the highest dose, increased cardiac output.

← Dopamina la migliore

← Dobutamina (no vasocostrizione)

← Adrenalina (peggioramento lattati)

Table 1—Mean ± SD values for cardiopulmonary parameters in 5 isoflurane-anesthetized cats before and during IV infusion of incremental doses of dopamine and 30, 60, and 90 minutes after the end of the infusion.

		Infusion rate (µg/kg/min)					Time after infusion (min)		
Parameter	**Baseline**	**2.5**	**5**	**10**	**15**	**20**	**30**	**60**	**90**
PCV (%)	29 ± 4	30 ± 5[f]	32 ± 5	37 ± 5	37 ± 6	42 ± 5[a,b]	32 ± 8	30 ± 7[f]	29 ± 5[f]
Lactate (mmol/L)	1.0 ± 0.3	1.1 ± 0.4	1.3 ± 0.5	1.0 ± 0.4	1.0 ± 0.4	0.9 ± 0.2	1.3 ± 0.4	1.3 ± 0.3	1.3 ± 0.2
Hb (g/dL)	10.70 ± 1.71	10.60 ± 1.37	12.42 ± 2.06	14.01 ± 1.71[a,b]	13.85 ± 2.20	14.20 ± 1.77[a,b]	11.72 ± 1.69	10.89 ± 1.73[f]	10.12 ± 1.22[d-f]
Temperature (°C)	37.8 ± 0.3	37.9 ± 0.2	38.1 ± 0.3	38.2 ± 0.2	38.3 ± 0.3	38.3 ± 0.3	38.2 ± 0.3	37.9 ± 0.4	37.6 ± 0.6
pH	7.352 ± 0.038	7.381 ± 0.050	7.386 ± 0.052	7.347 ± 0.064	7.355 ± 0.089	7.377 ± 0.080	7.369 ± 0.056	7.353 ± 0.029	7.352 ± 0.023
$Paco_2$ (mm Hg)	36.0 ± 5.0	32.4 ± 5.5	30.5 ± 4.8	33.7 ± 6.7	33.5 ± 8.6	30.7 ± 7.9	29.3 ± 4.3	30.5 ± 2.1	31.5 ± 1.6
Pao_2 (mm Hg)	512.4 ± 54.3	530.1 ± 42.9	525.9 ± 61.7	504.7 ± 57.9	530.9 ± 48.3	540.6 ± 67.5	513.7 ± 56.4	516.1 ± 57.7	520.8 ± 57.0
Cao_2 (mL/L)	142.7 ± 22.7	141.5 ± 18.1[d,f]	165.4 ± 27.3	186.4 ± 22.6[a,b]	184.4 ± 29.1	189.0 ± 23.4[a,b]	156.1 ± 22.3	145.2 ± 23.0[f]	135.1 ± 16.3[d-f]
$P\bar{v}o_2$ (mm Hg)	67.0 ± 16.3	70.8 ± 15.5	76.1 ± 13.8	81.8 ± 13.6	80.7 ± 13.2	77.2 ± 15.7	61.4 ± 4.0	60.0 ± 2.1	60.4 ± 1.5
$C\bar{v}o_2$ (mL/L)	125.4 ± 25.6	127.9 ± 20.4[d,f]	153.1 ± 28.0	173.5 ± 24.9[a,b]	171.7 ± 29.8[a]	174.1 ± 22.4[a,b]	135.0 ± 21.2	123.8 ± 21.4[d-f]	116.4 ± 14.2[d-f]
Venous admixture (%)	3.1 ± 1.0	3.5 ± 0.9	3.9 ± 1.1	4.2 ± 1.2	3.6 ± 1.0	3.2 ± 1.5	2.6 ± 1.0	2.4 ± 0.9	2.8 ± 1.3
HCO_3^- (mmol/L)	19.1 ± 1.5	18.3 ± 1.3	17.4 ± 1.3	17.5 ± 1.5	17.5 ± 1.5	16.9 ± 1.2	16.1 ± 0.8[a]	16.3 ± 0.7[a]	16.9 ± 0.6
BD (mmol/L)	–5.0 ± 1.3	–5.4 ± 0.9	–6.2 ± 1.1	–6.5 ± 1.3	–6.4 ± 0.9	–6.7 ± 0.6	–7.7 ± 0.7[a,b]	–7.7 ± 0.8[a,b]	–7.2 ± 0.8[a]
HR (beats/min)	156 ± 16	180 ± 19[e,f]	193 ± 21[a,e,f]	217 ± 17[a]	234 ± 16[a-c]	242 ± 16[a-c]	169 ± 14[d-f]	161 ± 15[c-f]	156 ± 17[c-f]
MAP (mm Hg)	68 ± 16	85 ± 19	94 ± 28	100 ± 22	105 ± 18	120 ± 31[a]	69 ± 12[f]	68 ± 12[f]	62 ± 7[e,f]
CVP (mm Hg)	6 ± 2	6 ± 2	5 ± 3	4 ± 2	5 ± 2	5 ± 2	8 ± 4	7 ± 4	8 ± 3
PAP (mm Hg)	16 ± 5	16 ± 4	20 ± 3	22 ± 5	23 ± 4	23 ± 5	17 ± 4	17 ± 5	14 ± 3
PAOP (mm Hg)	10 ± 5	10 ± 3	10 ± 3	10 ± 4	10 ± 2	11 ± 6	10 ± 5	10 ± 5	8 ± 4
CI (mL/min/m^2)	1,202 ± 355	1,762 ± 379[d-f]	2,056 ± 316[a]	2,551 ± 562[a,b]	2,703 ± 443[a,b]	2,494 ± 150[a,b]	1,262 ± 245[c-f]	1,242 ± 212[c-f]	1,242 ± 275[c-f]
SVI (mL/m^2)	7.9 ± 2.9	9.9 ± 2.5	10.8 ± 2.4[a]	11.8 ± 2.4[a]	11.6 ± 1.6[a]	10.4 ± 1.2	7.5 ± 2[c-f]	7.8 ± 1.6[c-e]	8.0 ± 2.0[c-e]
O_2 delivery (mL/min/m^2)	177 ± 77	254 ± 86[d-f]	343 ± 93[a,d]	479 ± 130[a-c]	496 ± 99[a-c]	472 ± 69[a,b]	196 ± 41[d-f]	178 ± 29[c-f]	163 ± 15[c-f]
$\dot{V}o_2$ (mL/min/m^2)	19.8 ± 6.1	22.7 ± 4.8	24.7 ± 5.1	31.6 ± 4.9	34.0 ± 4.9[a]	36.4 ± 12.7[a]	26.1 ± 6.1	26.2 ± 2.9	22.9 ± 2.5
Oxygen utilization ratio	0.126 ± 0.046	0.106 ± 0.049	0.082 ± 0.033	0.071 ± 0.025	0.071 ± 0.017	0.079 ± 0.031	0.136 ± 0.033[d,e]	0.149 ± 0.020[c-f]	0.141 ± 0.012[d,e]
SVRI (dynes·sec/cm^5·m^2)	4,369 ± 1,684	3,689 ± 1,219	3,481 ± 1,183	3,167 ± 1,144	3,004 ± 623[a]	3,700 ± 1,104	3,952 ± 833	4,033 ± 816	3,594 ± 924
PVRI (dynes·sec/cm^5·m^2)	431 ± 283	323 ± 228	395 ± 124	386 ± 110	414 ± 106	402 ± 123	449 ± 134	441 ± 119	405 ± 100

[a–f]Within a row, values with different superscript letters are significantly ($P < 0.05$) different from baseline values (a) and values obtained during administration of dopamine at infusion rates of 2.5 (b), 5 (c), 10 (d), 15 (e), and 20 (f) µg/kg/min.

Hb = Hemoglobin. $P\bar{v}o_2$ = Mixed venous partial pressure of oxygen. $C\bar{v}o_2$ = Mixed venous oxygen concentration. HCO_3^- = Bicarbonate. BD = Base deficit. HR = Heart rate. PAP = Pulmonary arterial pressure. PAOP = Pulmonary arterial occlusion pressure. CI = Cardiac index. O_2 = Oxygen consumption per unit of time.

Table 3—Mean ± SD values for cardiopulmonary parameters in 6 isoflurane-anesthetized cats before and during infusion of incremental doses of dobutamine and 30, 60, and 90 minutes after the end of the infusion.

		Infusion rates (µg/kg/min)					Time after infusion (min)		
Parameter	Baseline	2.5	5	10	15	20	30	60	90*
PCV (%)	27 ± 3	33 ± 6^{a}	36 ± 5^{a}	39 ± 5^{a}	41 ± 4^{a,b}	39 ± 3^{a}	31 ± 4^{a}	29 ± 3^{d-f}	30
Lactate (mmol/L)	1.0 ± 0.4	1.1 ± 0.4^{b}	1.3 ± 0.4	1.5 ± 0.5	1.7 ± 0.5^{a}	2.0 ± 0.5^{a,b}	1.8 ± 0.4^{a}	1.5 ± 0.3	1.1
Hb (g/dL)	10.06 ± 1.73	13.89 ± 2.38	13.32 ± 2.19	14.08 ± 2.09^{a}	14.52 ± 1.84^{a}	13.48 ± 2.42	11.21 ± 2.36	10.98 ± 13.9	11.14
Temperature (°C)	37.3 ± 0.3	37.8 ± 0.3	37.9 ± 0.3	38.0 ± 0.3^{a}	38.0 ± 0.3^{a}	38.2 ± 0.3^{a}	38.0 ± 0.4^{a}	37.9 ± 0.5^{a}	37.4
pH	7.375 ± 0.080	7.369 ± 0.082	7.387 ± 0.063	7.388 ± 0.074	7.391 ± 0.063^{a}	7.392 ± 0.062^{a}	7.393 ± 0.030^{a}	7.401 ± 0.044	7.361
$Paco_2$ (mm Hg)	36.0 ± 7.5	35.8 ± 9.3	31.9 ± 6.9	30.5 ± 7.2	30.0 ± 6.4	28.3 ± 6.3	27.8 ± 2.8	28.3 ± 3.6	32.2
Pao_2 (mm Hg)	542.3 ± 36.5	558.9 ± 38.0	565.0 ± 25.0	569.8 ± 26.0	571.6 ± 24.2	566.5 ± 16.2	554.1 ± 21.8	559.1 ± 26.4	515.5
Cao_2 (mL/L)	134.4 ± 22.8	184.9 ± 31.4	177.5 ± 28.9	187.5 ± 27.6^{a}	193.3 ± 24.2^{a}	179.6 ± 32.0	149.6 ± 31.2	146.6 ± 18.4	148.6
$P\bar{v}o_2$ (mm Hg)	63.8 ± 9.6	90.4 ± 22.9	109.6 ± 21.0^{a}	111.5 ± 16.6^{a}	111.3 ± 12.9^{a}	107.7 ± 15.6^{a}	61.6 ± 8.5^{b-f}	60.2 ± 5.2^{b-f}	4.2
$C\bar{v}o_2$ (mL/L)	118.7 ± 21.3	174.5 ± 32.1^{a}	170.6 ± 28.2^{a}	181.4 ± 27.1^{a}	187.1 ± 23.6^{a}	173.2 ± 30.1^{a}	129.3 ± 23.3^{d,e}	127.4 ± 14.9^{d,e}	128.7
Venous admixture (%)	2.9 ± 1.3	3.3 ± 1.4	5.5 ± 1.9	5.6 ± 1.4	5.5 ± 1.6	5.9 ± 2.3^{a}	2.4 ± 1.2^{c-f}	2.2 ± 1.0^{c-f}	2.6
HCO_3^- (mmol/L)	20.0 ± 1.5	19.3 ± 2.2^{f}	18.1 ± 1.4	17.3 ± 1.3^{a}	17.2 ± 1.3^{a}	16.3 ± 1.3^{a,b}	16.2 ± 0.8^{a,b}	16.8 ± 0.8^{b}	17.6
BD (mmol/L)	−3.9 ± 1.0	−4.5 ± 1.4^{d-f}	−5.5 ± 0.8^{a,f}	−6.3 ± 0.6^{a,b}	−6.3 ± 0.6^{a,b}	−7.2 ± 0.7^{a-c}	−7.3 ± 0.7^{a-c}	−6.6 ± 0.6^{a,b}	−6.3
HR (beats/min)	155 ± 23	189 ± 13$^{a,d-f}$	207 ± 17^{a,f}	225 ± 12^{a,b}	231 ± 10^{a,b}	235 ± 8^{a-c}	165 ± 12^{c-f}	164 ± 10^{c-f}	170
MAP (mm Hg)	70 ± 13	77 ± 12	91 ± 11	86 ± 13	88 ± 17	86 ± 13	82 ± 21	77 ± 15	83
CVP (mm Hg)	6 ± 1	5 ± 2	5 ± 2	6 ± 3	6 ± 2	6 ± 3	10 ± 1^{b,c}	10 ± 2^{a-c}	8
PAP (mm Hg)	12 ± 5	13 ± 4	14 ± 5	15 ± 5	16 ± 5	16 ± 5	15 ± 5	15 ± 5	16
PAOP (mm Hg)	6 ± 5	7 ± 4	9 ± 4	9 ± 6	8 ± 5	7 ± 5	9 ± 5	10 ± 6	6
CI (mL/min/m²)	1,316 ± 411	2,400 ± 900	2,579 ± 658^{a}	2,929 ± 706^{a}	3,272 ± 824^{a}	3,254 ± 664^{a}	1,247 ± 286^{c-f}	1,226 ± 238^{c-f}	1,337
SVI (mL/m²)	8.6 ± 2.9	12.8 ± 4.9^{a}	12.7 ± 3.9^{a}	13.1 ± 3.5^{a}	14.3 ± 3.9^{a}	13.9 ± 3.0^{a}	7.6 ± 1.5^{b-f}	7.4 ± 1.1^{b-f}	7.9
O_2 delivery (mL/min/m²)	181 ± 84	450 ± 200	463 ± 161	557 ± 187^{a}	639 ± 207^{a}	590 ± 184^{a}	184 ± 43^{d-f}	179 ± 36^{d-f}	188
$\dot{V}o_2$ (mL/min/m²)	19.8 ± 6.3	22.4 ± 4.2	17.3 ± 8.1	17.5 ± 4.1	19.7 ± 4.4	20.5 ± 8.0	23.8 ± 9.1	22.5 ± 4.6	25.2
O_2 utilization ratio	0.117 ± 0.036	0.074 ± 0.052	0.039 ± 0.019^{a}	0.033 ± 0.009^{a}	0.032 ± 0.009^{a}	0.035 ± 0.010^{a}	0.131 ± 0.045^{c-f}	0.130 ± 0.033^{c-f}	0.134
SVRI (dynes·sec/cm⁵·m²)	4,164 ± 1205	2,527 ± 517	2,746 ± 510	2,268 ± 537^{a}	2,124 ± 695^{a}	2,049 ± 643^{a}	4,850 ± 1,929^{b-f}	4,447 ± 924$^{b,d-f}$	4,764
PVRI (dynes·sec/cm⁵·m²)	339 ± 137	229 ± 115	185 ± 112	174 ± 103	216 ± 121	249 ± 135	443 ± 304^{c,d}	407 ± 313	641

[a–f]Within a row, values with different superscript letters are significantly ($P < 0.05$) different from baseline values (a) and values obtained during administration of dobutamine at infusion rates of 2.5 (b), 5 (c), 10 (d), 15 (e), and 20 (f) µg/kg/min.

*Calculated by use of values from only 1 cat.

See Table 1 for remainder of key.

Table 4—Mean ± SD values for cardiopulmonary parameters in 6 isoflurane-anesthetized cats before and during IV infusion of incremental doses of epinephrine and 30, 60, and 90 minutes after the end of the infusion.

		Infusion rate (µg/kg/min)					Time after infusion (min)		
Parameters	**Baseline**	**0.125**	**0.25**	**0.5**	**1.0**	**2.0**	**30**	**60**	**90***
PCV (%)	26 ± 3	39 ± 5[a]	40 ± 6[a]	41 ± 5[a]	42 ± 5[a]	43 ± 5[a]	33 ± 5[e,f]	31 ± 5[c-f]	30 ± 5[c-f]
Lactate (mmol/L)	1.0 ± 0.5	3.3 ± 0.6[b-f]	4.9 ± 0.6[a,b]	5.5 ± 0.8[a,b]	4.9 ± 0.8[a,b]	4.7 ± 1.0[a,b]	3.4 ± 0.8[c-e]	2.2 ± 0.7[c-f]	1.7 ± 0.4[b-f]
Hb (g/dL)	10.64 ± 1.46	14.66 ± 15.1[a]	15.12 ± 2.00[a]	15.05 ± 18.0[a]	15.64 ± 2.14[a]	15.19 ± 2.29[a]	12.82 ± 2.08	11.69 ± 2.00[e]	11.25 ± 1.59[f]
Temperature (°C)	37.8 ± 0.3	38.0 ± 0.1[f]	38.2 ± 0.3	38.3 ± 0.3	38.3 ± 0.4	38.5 ± 0.2[a,b]	38.2 ± 0.3	38.0 ± 0.2[f]	37.8 ± 0.3[f]
pH	7.359 ± 0.054	7.332 ± 0.052	7.303 ± 0.047[a]	7.299 ± 0.045[a]	7.298 ± 0.057	7.288 ± 0.056	7.353 ± 0.048[e,f]	7.405 ± 0.040[b-f]	7.377 ± 0.024[c-f]
Pa_{CO_2} (mm Hg)	36.0 ± 5.1	30.8 ± 5.8	29.2 ± 4.4	28.6 ± 5.7	30.9 ± 8.2	32.0 ± 8.1	27.4 ± 5.7	26.0 ± 4.8	29.0 ± 2.7
Pa_{O_2} (mm Hg)	422.1 ± 154.6	490.2 ± 85.7	519.8 ± 84.5	515.0 ± 81.1	398.3 ± 164.7	496.8 ± 93.1	476.3 ± 121.0	513.7 ± 75.7	493.7 ± 76.6
Ca_{O_2} (mL/L)	141.4 ± 19.7	194.8 ± 19.9[a]	201.0 ± 26.5[a]	200.1 ± 23.9[a]	207.2 ± 28.8[a]	201.8 ± 30.4[a]	170.5 ± 27.3	155.8 ± 26.4[a]	149.9 ± 21.0[a]
$P\bar{v}_{O_2}$ (mm Hg)	65.6 ± 9.3	88.8 ± 18.5	93.3 ± 12.2[a]	93.2 ± 13.9[a]	95.1 ± 11.7[a]	99.2 ± 18.8[a]	62.1 ± 7.2[c-f]	58.7 ± 9.0[b-f]	60.1 ± 8.2[f]
$C\bar{v}_{O_2}$ (mL/L)	124.9 ± 17.9	180.7 ± 21.3[a]	190.1 ± 27.7[a]	188.9 ± 25.4[a]	197.0 ± 29.6[a]	190.4 ± 29.6[a]	147.0 ± 26.5[a]	133.5 ± 22.8[c-f]	129.5 ± 20.6[a]
Venous admixture (%)	6.8 ± 7.1	5.3 ± 4.1	4.6 ± 2.7	4.8 ± 2.4	10.9 ± 9.0	5.7 ± 3.2	3.3 ± 2.9	2.7 ± 1.7	3.2 ± 2.0
HCO_3^- (mmol/L)	19.4 ± 1.1	15.5 ± 1.3[a]	13.8 ± 1.0[a]	13.3 ± 1.4[a]	14.2 ± 2.0[a]	14.4 ± 1.9[a]	14.4 ± 1.8[a]	15.5 ± 1.7[a]	16.4 ± 1.2[d]
BD (mmol/L)	–4.5 ± 1.1	–8.7 ± 0.8[a,c,d]	–10.7 ± 0.9[a]	–11.2 ± 1.2[a]	–10.3 ± 1.4[a]	–10.2 ± 1.3[a]	–9.5 ± 1.3[a]	–7.9 ± 1.4[a,c-f]	–7.3 ± 1.2[a,c-f]
HR (beats/min)	163 ± 18	191 ± 11[a]	194 ± 9[a]	204 ± 6[a]	212 ± 6[a]	211 ± 18[a]	170 ± 19[d-f]	173 ± 11[d-f]	167 ± 8[c-f]
MAP (mm Hg)	67 ± 5	83 ± 20[e,f]	88 ± 20[e,f]	119 ± 27[a]	134 ± 15[a-c]	139 ± 36[a-c]	73 ± 10[d-f]	75 ± 14[d-f]	65 ± 6[d-f]
CVP (mm Hg)	10 ± 2	12 ± 3	11 ± 2	11 ± 2	9 ± 2	9 ± 3	9 ± 2	10 ± 3	11 ± 2
PAP (mm Hg)	16 ± 2	24 ± 2[a]	24 ± 2[a]	23 ± 5[a]	24 ± 4[a]	23 ± 4[a]	16 ± 1[b-f]	17 ± 3[b,c,e]	17 ± 3[b,c,e,f]
PAOP (mm Hg)	9 ± 3	11 ± 5	11 ± 4	12 ± 3	10 ± 1	11 ± 3	7 ± 3	8 ± 2	8 ± 4
CI (mL/min/m²)	1,221 ± 336	1,924 ± 656	2,205 ± 692	2,417 ± 546[a]	2,645 ± 722[a]	2,591 ± 704[a]	1,566 ± 293[a]	1,369 ± 257[d-f]	1,330 ± 328[e,f]
SVI (mL/m²)	7.4 ± 1.4	9.9 ± 2.8[a]	11.3 ± 3.1[a]	11.9 ± 2.6[a]	12.5 ± 3.6[a,b]	12.3 ± 3.2[a,b]	9.2 ± 1.6[d-f]	7.9 ± 1.5[c-f]	7.9 ± 1.6[c-f]
O_2 delivery (mL/min/m²)	173 ± 59	379 ± 149	449 ± 169[a]	483 ± 115[a]	554 ± 182[a]	531 ± 178[a]	264 ± 52[e,f]	214 ± 58[d-f]	200 ± 60[e,f]
$\dot{V}_{O_2}$ (mL/min/m²)	19.6 ± 5.4	21.2 ± 13.3	23.0 ± 2.6	26.5 ± 5.9	26.5 ± 6.9	29.4 ± 11.3	35.4 ± 8.4[a-c]	29.3 ± 8.8	25.8 ± 6.9
O_2 utilization ratio	0.117 ± 0.031	0.062 ± 0.023	0.056 ± 0.017	0.057 ± 0.019	0.051 ± 0.017[a]	0.057 ± 0.025[a]	0.139 ± 0.046[b-f]	0.142 ± 0.045[b-f]	0.137 ± 0.048
SVRI (dynes·sec/cm⁵·m²)	3,990 ± 1,048	3,288 ± 1,602	2,950 ± 963	3,730 ± 1,110	4,013 ± 1,119	4,199 ± 1,445	3,408 ± 901	3,873 ± 888	3,515 ± 691
PVRI (dynes·sec/cm⁵·m²)	452 ± 123	587 ± 189	509 ± 201	381 ± 168	424 ± 79	386 ± 101	455 ± 116	549 ± 166	590 ± 218

[a-f]Within a row, values with different superscript letters are significantly ($P < 0.05$) different from baseline values (a) and values obtained during administration of epinephrine at infusion rates of 0.125 (b), 0.25 (c), 0.5 (d), 1.0 (e), and 2.0 (f) µg/kg/min.

*Calculated by use of values from 4 or 5 cats.

See Table 1 for key.

Dobutamina

not examined. Results of our study indicated that dobutamine increased heart rate and CI in a dose-dependent manner and the effect on cardiac output and contractility appeared to be greater than for dopamine or epinephrine at the doses used. Systemic

effects.[20] This decrease in systemic vascular resistance contributed to the lack of a significant effect on MAP despite the increase in CI; however, all cats had an MAP > 70 mm Hg during administration of dobutamine at an infusion rate of 5 µg/kg/min.