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ROLE OF VAGAL AND SINOAORTIC BAROREFLEXES IN RESTORATION OF ARTERIAL PRESSURE AFTER ACUTE MILD HAEMORRHAGE IN RABBITS

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Abstract : To evaluate the contribution of vagal and sinoarotic baroreflexes (SBR) in circulatory adjustments, anaesthetized rabbits were subjected to acute mild haemorrhage and the extent of recovery produced after haemorrhage was estimated. The recovery of arterial pressure after acute mild haemorrhage with reflexes intact was 96.19%, after elimination of SBR it was 79.20%, after bilateral vagotomy 87.38%, and after eliminating both reflex systems it was 75.66%. The results suggest that vagally mediated baroreflexes from cardiopulmonary baroreceptors contribute significantly in restoring the arterial pressure in response to haemorrhage while the sinoaortic baroreflexes play the major role.

Key words : acute mild haemorrhage sinoaortic baroreflex vagally mediated barorelfex

INTRODUCTION

Mild hypotension is a common feature in surgical practice and is readily buffered by in-built baroreflexes. The integrity of sinoaortic and vagally mediated cardiopulmonary baroreflexes is essential for buffereing such alterations in arterial pressure (AP). In the absence of these baroreflexes, haemorrhage leads to a greater fall in AP (1, 2). The afferents from the arterial baroreceptors are shared by the neural reflexes controlling AP. Sinoaortic baroreflexes are known to be primarily responsible for cardiovascular homeostasis (3,4,5). However, the role of vagal reflexes remains controversial (3, 4, 6) 7. A study of the contribution of vagal baroreflexes is complicated by the simultaneous buffering function by sinoaortic baroreflexes; as well as the possible interaction between them at the level of the central nervous system (3, 8, 9).

In the present study we have investigated quantitatively the contribution of vagal and sinoaortic baroreflexes (when each acts independently of the other) by evaluating the extent of recovery of AP in response to acute mild haemorrhage in anaesthetized rabbits.

METHODS

The experiments were performed on thirty rabbits of either sex weighing between one to two kg (mean 1.86±0.08). After anaesthesia (sodium nembutal 30-40 mg/kg body weight) the trachea was cannulated in the midcervical region. The vagi were exposed on both sides in the cervical region and separated from the carotid sheath. The aortic nerves were isolated from the surrounding tissue and cleaned; ligatures were loosely tied around them. The carotid sinus was exposed on both sides. The femoral arteries of both sides were exposed and cannulated. The right femoral artery was connected through a three-way adapter to a pressure transducer (strain gauge type) which was connected to a two channel recorder (Polyrite INCO). Adjustments in the recording channel were made to record the mean arterial pressure directly. Heart rate was recorded through E.C.G. on the second channel. The left femoral artery was cannulated for producing haemorrhage. The femoral vein was cannulated for retransfusion of blood and intermittant injection of anaesthetic.

Denervation procedure: Denervation was car-

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ried out using the procedure described by Katoh et al (4). The rabbits were classified into three groups. In group I (n=10) the sinoaortic baroreflexes were eliminated by bilateral section of sinus and aortic nerves, and by thorough stripping of the area of the carotid bifurcation. (The completeness of the denervation of carotid sinus baroreceptors was tested by checking the blood pressure response to bilateral carotid occlusion). In group III (n=10) the vagally mediated cardiopulmonary baroreflexes were eliminated by bilateral cervical vagotomy. In group III (n=10) both vagal and sinoaortic baroreflexes were eliminated.

Haemorrhage: A standard blood loss of 10% blood volume was induced assuming the total blood volume to be 65 ml/kg (4). Blood was withdrawn at a constant speed from the left femoral artery through a cannula with large bore. Four minues were allowed for haemodynamic measurements before the blood was reinfused at the same speed. This short duration of blood loss was chosen to minimize tissue hypoxia and changes in circulating catacholamines.

Protocol: The baseline mean arterial pressure (MAP) and heart rate (HR) were recorded before inducing haemorrhage, and were monitored throughout the experiment. First, a control haemorrhage was done with reflexes intact. Ten percent of the total blood volume was withdrawn rapidly (in 30-40 sec), and alterations in MAP and HR were monitored for a period of four minutes after completion of haemorrhage. This was followed by transfusion of the withdrawn blood. MAP and HR were allowed to stabilize. Bilateral section of sinus and aortic nerves was done (Group I) and the effects on MAP and HR recorded. This was followed by a second haemorrhage produced in a manner identical to that for control haemorrhage. Changes in MAP and HR were again recorded. The same procedure was used in each group of animals. Arterial blood pH, PCO_2 and PO_2 were maintained within normal range by analysing the arterial samples every 30 min to 1 hr (Radiometer, ABL 3).

Statistical analysis: The mean and standard error (SE) for MAP and HR at 1, 2, 3, and 4 min following control haemorrhage were calculated and compared with prehaemorrhage values. Values observed following haemorrhage after denervation were compared with the basal values and those obtained after control haemorrhage in each group. Comparisons were made using paired t-tests. The probability values of 0.05 and below were considered significant.

RESULTS

A. CHANGES IN MEAN ARTERIAL PRESSURE

The values of MAP following haemorhage before and after denervation are given in Table I.

Effects of control haemorrhage: Fig. 1 shows that acute haemorrhage (10%) with reflexes intact produced a fall in MAP of 28.01% which was maximal at approximately one minute after haemorrhage. The fall in MAP was followed by progressive recovery. MAP recovered to 82.76% (of prehaemorrhage value) at 2 min, 87.67% at 3 min, and 96.19% at 4 min after a 10% induced haemorrhage. (The values quoted are the means of control values in animals of the three groups).

Effect of elimination of baroreflexes: Bilateral vagotomy (to eliminate vagally mediated cardiopulmonary baroreflexes) increased MAP by 21.61% ($P < 0.001$); which was greater than the effect produced by elimination of sinoaortic baroreflexes (15.61%, $P<0.001$). A combination of bilateral vagotomy and elimination of sinoaortic baroreflexes increased the MAP to 25.33% ($P<0.001$).

Changes in MAP following haemorrhage after denervation Group I: After denervation of sinoaoratic baroreceptors haemorrhage produced a fall in MAP by 50.04% ($P<0.001$). By 2 min the MAP has recovered to 69.48% of the prehaemorrhage value, while at 4 min it was 79.20% of the prehaemorrhage MAP ($P<0.01$) indicating considerable impairment of recovery at various points as compared to the respective control values (Table I).

Group II: Following elimination of vagal reflexes haemorrhage reduced the MAP (at 1 min) by

TABLE I : Effect of haemorrhage (10%) on mean arterial pressure (mmHg) with reflexes intact and after denervation. (Values are mean±SE).

Group		*Before haemorrhage*	*After Haemorrhage*			
			1 min	*2 min*	*3 min*	*4 min*
Group I	Control	93.40	65.90	76.90	80.90	89.80
	Haemorrhage	±3.94	±5.79	±6.66	±6.10	±4.48
	P value		<0.001	<0.01	<0.01	<0.02
	Haemorrhage after SABD	95.10 ±3.13	48.00 ±4.97	66.60 ±6.49	72.70 ±7.13	75.40 ±7.12
	P value		<0.001	<0.001	<0.01	<0.01
Group II	Control	101.10	71.30	84.80	92.40	97.10
	Haemorrhage	±4.59	±5.94	±4.89	±4.44	±3.95
	P value		<0.001	<0.001	<0.01	<0.05
	Haemorrhage after BV	110.10 ±5.39	70.20 ±6.96	86.30 ±5.70	92.90 ±6.01	96.10 ±5.97
	P value		<0.001	<0.01	<0.05	<0.05
Group III	Control	99.90	76.50	87.20	91.50	96.90
	Haemorrhage	±4.98	±6.05	±5.21	±5.01	±4.76
	P value		<0.001	<0.01	<0.02	NS
	Haemorrhage after SABD & BV	104.20 ±4.71	49.80 ±7.32	69.10 ±4.64	77.80 ±5.26	79.20 ±5.20
	P value		<0.001	<0.001	<0.001	<0.001

P values indicate the significance of the difference of MAP at 1,2,3,4 min after haemorrhage from prehaemorrhage values.
SABD = sinoaortic baroreceptor denervation. BV = bilateral vagotomy.

TABLE II : Effect of haemorrhage (10%) on heart rate (beats/min) with reflexes intact and after denervation. (Values are mean ±SE).

Group		*Before haemorrhage*	*After haemorrhage*			
			1 min	*2 min*	*3 min*	*4 min*
Group I	Control	235.00	245.60	240.50	240.20	240.50
	Haemorrhage	±4.64	±14.97	±13.66	±12.96	±13.06
	P value		<0.001	NS	NS	NS
	Haemorrhage after SABD	217.40 ±15.59	223.40 ±16.24	223.10 ±15.55	223.80 ±16.15	223.80 ±15.69
	P value		<0.05	NS	NS	NS
Group II	Control	248.20	262.80	258.60	254.00	255.40
	Haemorrhage	±8.00	±9.50	±9.36	±8.87	±9.44
	P value		<0.01	NS	NS	NS
	Haemorrhage after BV	234.00 ±8.62	242.40 ±9.09	246.60 ±10.30	241.80 ±10.08	239.40 ±9.40
	P value		<0.02	<0.01	<0.05	<0.05
Group III	Control	220.20	240.60	238.40	236.40	235.60
	Haemorrhage	±13.09	±13.58	±13.12	±12.12	±11.95
	P value		<0.01	<0.01	<0.01	<0.01
	Haemorrhage after SABD & BV	198.40 ±10.42	204.40 ±10.70	200.80 ±10.86	199.60 ±11.04	198.40 ±10.22
	P value		<0.001	NS	NS	NS

P Values indicate the significance of the difference of HR at 1,2,3,4 min after haemorrhage from prehaemorrhage values.
SABD = sinoaortic baroreceptor denervation; BV = bilateral vagotomy.

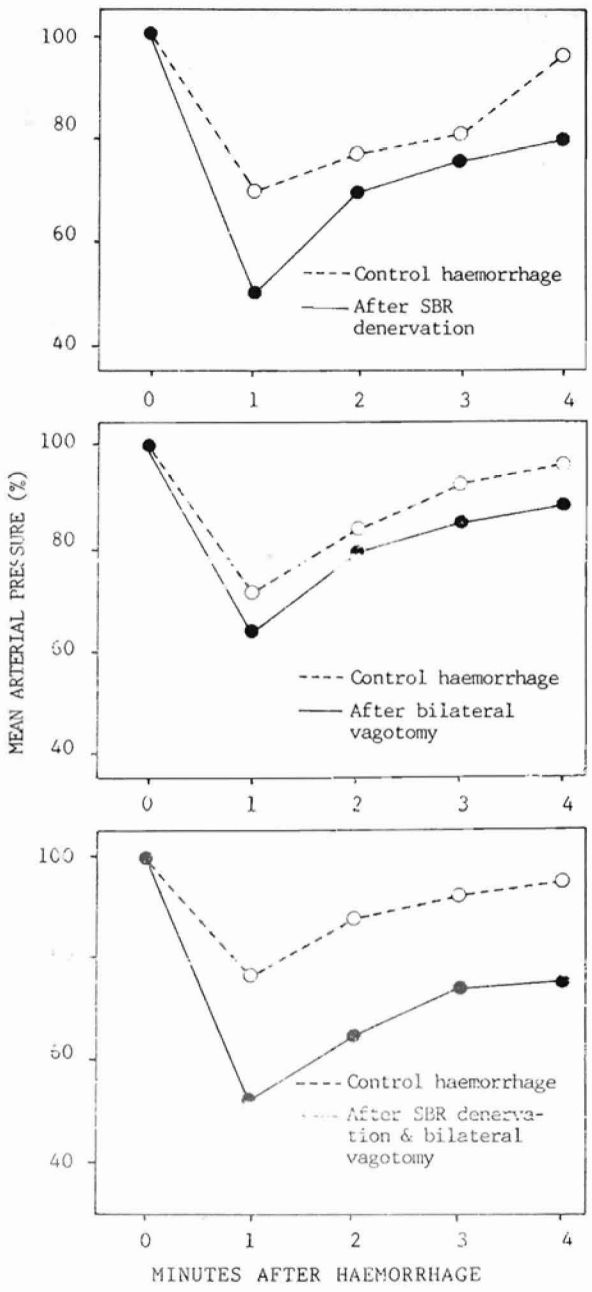

Fig. 1. Fall in mean arterial pressure (expressed as percentage of basal value) in response to acute haemorrhage (10%) in rabbits: A. After denervation of sino-aortic baroreceptors (SABD); B. After bilateral vagotomy (BV); C. After SABD and BV. Each point represents mean of ten observations. Control values with reflexes intact are also shown.

37.00% ($P<0.02$) of the base line value. The MAP recovered at 4 min to 87.38% showing significant ($P<0.02$) impairment as compared to the control haemorrhage. The extent of recovery in group II was greater than in group I (Fig. 1).

Group III: Following elimination of both vagal and sinoaortic baroreflexes, haemorrhage produced greater fall in MAP (52.69%, $P<0.001$) than the fall in MAP observed in groups I and II. The recovery of MAP (at 4 min after haemorrhage) was considerably less (75.66% of baseline value, $P<0.001$) than that observed in groups I and II (Table 1, Fig. 1).

B. HEART RATE

Following haemorrhage (with reflexes intact) there was a small but significant increase in HR (average 6.55%, $P<0.01$) as compared to the pre-haemorrhage values. The maximum increase in HR was noted at 1 min after haemorrhage, corresponding with maximum fall in MAP.

After elimination of vagal and sinoaortic baroreflexes, the posthaemorrhagic increase in HR was 3.62% and 3.23% respectively. The increase in HR was insignificant when compared with respective control values (Table II); and the intergroup differences were not appreciable.

DISCUSSION

Quick mild haemorrhage was used to quantify the role of vagally mediated cardiopulmonary baroreflexes (VBR) and sinoaortic baroreflexes (SBR). When haemorrhage is quick and its volume small, the resultant changes in arterial pressure (AP) are exclusively representative of the role of baroreflexes in buffering the AP (without affecting the chemoreceptor responses). The fall of AP deactivates the baroreceptors producing a reflex increase in peripheral vascular resistance, HR and myocardial contractility, which in turn tend to restore the AP. In the present study the post-haemorrhage hypotension and the extent of recovery produced by the baroreflexes was evaluated (i) with both reflexes intact; (ii) after eliminating vagal reflexes; (iii) after

eliminating sinoaortic baroreflexes and (iv) with both reflexes abolished. The present observations show that the recovery of MAP (following acute mild haemorrhage) after elimination of SBR was 79.02%, and after elimination of VBR it was 87.38% (Fig. 1) indicating that quantitatively SBR are more powerful in moderating the AP than VBR. This is in conformity with the well documented fact that SBR are of overwhelming importance after haemorrhage (3,4,5).

Although some workers have questioned the role played by VBR in such adjustments (2,3,4) there is considerable evidence that vagal afferents from cardiopulmonary baroreceptors contribute to the regulation of circulation by exerting an inhibitory influence on sympathetic outflow (7,10,11). Interruption of vagal nerve traffic from the cardiopulmonary region has been found to result in wide spread sympathetically mediated vasoconstriction (12). Bishop and Barron (8) have shown that in the presence of intact arterial baroreceptors vagal cold block caused a significant increase in MAP, in cardiac output, and in HR. Recently Dikshit (1) has reported that lower body subatmospheric pressure less than 30 mmHg deactivates the low pressure cardiopulmonary baroreceptors and reflexly increases the limb vascular resistance. Abboud et al (13) have emphasized that both SBR and VBR increase the vascular resistance in response to low AP. However, the SBR mainly affect the peripheral resistance of splanchnic vessels and VBR predominantly influence the forearm vascular resistance. The quantitative differences observed in the present study show the following. (1) With both reflexes intact, fall in AP following haemorrhage was restricted to about 28% of baseline value. After BV the fall was about 37% showing that SBR acting alone were unable to restrict the fall in AP to the control level. The difference of about 9% (of baseline value) may be regarded as the contribution of VBR in buffering fall of AP (2). With both reflexes intact, AP had recovered at 4 min to about 98% of baseline value. After BV the recovery was about 87%. Again, SBR acting alone were unable to bring AP to the control level. The shortfall of about 9% may be regarded as the contribution of VBR in restoring AP. On the basis of the findings of the present study and those of various workers quoted above, it is concluded that VBR contribute significantly in circulatory adjustments following haemorrhage.

Regarding the contribution of HR in circulatory adjustments of haemorrhage, the present observations and those of some previous workers (3,4) suggest that changes in HR play a relatively minor role in the compensation for posthaemorrhage hypotension, particularly in rabbits who have a high baseline HR(14).

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