Observations on the Circulation of Domestic Cattle

By JOSEPH T. DOYLE, M.D., JOHN L. PATTERSON, JR., M.D.,
JAMES V. WARREN, M.D., and DAVID K. DETWELLER, V.M.D.

With the assistance of Monica Reynolds, Ph.D.

Comparative physiology has much to contribute to our understanding of the circulation. For this purpose large animals until recently have been neglected as subjects of circulatory studies by modern techniques, yet nature's means of solving the circulatory problems which these animals present are of great interest and, in case of domestic cattle (Bos taurus), of obvious practical importance. Intravascular and intracardiac pressures were recorded, and cardiac output and related functions were measured, or calculated, and related to body size. The effects of environmental stimuli and of phonation ("moo") were observed. Interesting differences between the findings in the cow and those in normal man and in the giraffe are made the subject of comment.

SYSTEMATIC observations of cardiorespiratory functions, employing modern techniques, have only recently been attempted on large animals. Such observations, in addition to their inherent interest, should be of importance to the fields of veterinary medicine and comparative physiology. These general considerations, as well as the particular desire to obtain data for comparison with similar observations in the giraffe, prompted the present studies.

Female domestic cattle (Bos taurus), hereinafter referred to as cows, were elected for study not only because of their ready availability but also because of their kinship to the giraffe. These animals are both ruminants belonging to the sub-order Pecora, but belonging to different families, the Bovidae and Giraffidae respectively. Cows and giraffe are of about the same weight, with considerable similarity in internal anatomy but with certain striking anatomical contrasts related primarily to difference in height. Of these the most notable are the much greater vertical heart to brain distance and the much longer trachea in the giraffe.

Methods

The principal studies were done on 12 cows (table 1); intracardiac pressures alone were measured on an additional animal (Cow XVII). Respiratory studies, to be reported elsewhere, were performed on a number of the same animals, and in some cases respiratory studies only were done. For this reason, there are gaps in the consecutive numbering of the animals. All animals were healthy on physical examination. Animals I to IV and VIII, were nonpregnant and in the late lactation period. Cows VIII and IX were re-studied 7 months later when they became pregnant. The remaining animals were nonpregnant, but their lactational status is not known. Cow XVII was studied on a private farm prior to her destruction, made necessary by arthritis which had prevented her rising to her feet for 3 days. The autopsied heart of this animal disclosed normal valves and grossly and microscopically normal ventricular myocardium. The lungs were grossly and microscopically normal except for bronchopneumonia in the right lower lobe, and considerable general capillary engorgement.

The animals were kept standing in stanchions, with the head in the usual nonfeeding position, except Cow XVII, which was in the right lateral decubitus position. A nose lead was used as necessary for further restraint. The tension on the lead was relaxed following the surgical procedures; in Cow VIII the lead was hanging without tension and in Cow IX it was removed. An electrocardiogram was obtained by implanting needle electrodes in the skin over the cephalic angle of the right scapula and over the fifth left
Table 1

<table>
<thead>
<tr>
<th>Cow</th>
<th>Breed</th>
<th>Weight Kg</th>
<th>Body Surface Area M²</th>
<th>Hemoglobin Gm./100 ml</th>
<th>Hematocrit Reading %</th>
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<tr>
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<td>5.72</td>
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*Body weight derived from dressed weight multiplied by 1.83 (mean ratio in 20 abattoir animals).
†Estimated.

The hemoglobin concentration was estimated from the oxygen capacity of the blood or from the density of hemolysed blood at 507 m∠, read in the Beckman Model B spectrophotometer. In one animal, Cow I, the cardiac output was determined by the direct Fick method by measuring the oxygen consumption (open-circuit method) and the simultaneous systemic arterial-pulmonary arterial oxygen difference. In the other animals cardiac output was measured by the indicator-dilution technique. Ten ml. (50 mg.) of T-1824 (Warner-Chilcott Laboratories) in a calibrated syringe were rapidly injected through the catheter lying in the right atrium in the first 4 animals. In Cow XIV 10 ml. (25 mg.) of indoxyline green (Hynson, Westcott and Dunning, Inc.) and in animal XVI 15 ml. (37.5 mg.) were similarly injected. Simultaneously with the injection of the indicator, art-

intercostal space at the level of the upper aspect of the olecranon. The carotid artery and the jugular vein in the mid-third of the neck were dissected free under local anesthesia. In the first 4 cows arterial blood samples were drawn and pressures were measured through a short length of polyethylene 260 (I.D. 1.77 mm.) tubing fitted with a Luer adapter and stopcock. The tubing was tied into the artery and directed centrally. In the same animals PE 190 (I.D. 1.19 mm.) tubing was passed blindly through the jugular vein into the right atrium, the right ventricle and in a number of instances into the pulmonary artery. In the rest of the animals PE 205 (I.D. 1.57 mm.) tubing was used for arterial catheterization except in cows VIII (1, 2) and IX, in which PE 90 (I.D. 0.86 mm.) tubing was used for all purposes. Intravascular pressures were measured with Statham P23AA, P23BB and P23D strain gages calibrated against a mercury manometer. The transducers were placed at the palpated heart level in the first 4 animals. In the remaining animals, heart level was assumed to be the level of the olecranon with the foreleg straight. In the lateral projection of the animal, this point is seen to lie very near the center of the cardiac silhouette. The pressure, respiratory and electrocardiographic recordings were made on a Sanborn direct-writing multichannel polyoscillograph. Values for mean pressures were obtained by polar planimetry of records taken at 25 or 50 mm./sec., in which artefact was slight or absent. The degree of high frequency artefact present in the pressure tracings was judged visually, and arbitrarily classified as 1+, 2+ and 3+. The use of PE 90* (I.D. 0.86 mm.) tubing resulted in the best contours but made blood sampling more difficult.

Blood samples were drawn anaerobically and promptly iced. Gasometry and the measurement of the hydrogen ion concentration were carried out using standard methods. The hemoglobin concentration was estimated from the oxygen capacity of the blood or from the density of hemolysed blood at 507 m∠, read in the Beckman Model B spectrophotometer.
Table 2

Intramascular Pressures and Heart Rates

<table>
<thead>
<tr>
<th>Cow</th>
<th>Right atrium mm. Hg</th>
<th>Right ventricle mm. Hg</th>
<th>Pulmonary artery mm. Hg</th>
<th>Carotid artery mm. Hg</th>
<th>Heart rate beats/min.</th>
<th>Highest</th>
<th>Lowest</th>
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<tr>
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<td>48/-4/10 (**)</td>
<td>52/13 (30)</td>
<td>28.6Δ</td>
<td>244/181 (215)</td>
<td>218Δ</td>
<td>64</td>
<td>50</td>
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<tr>
<td>II</td>
<td>80/-4/12 (**)</td>
<td>80/20 (44)</td>
<td>188/144 (164)</td>
<td>188Δ</td>
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<td>68</td>
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<tr>
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<td>50/-10/4** (**)</td>
<td>36/20 (30)**</td>
<td>144/107</td>
<td>148/131 (149)</td>
<td>156Δ</td>
<td>112†</td>
<td>100†</td>
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<tr>
<td>IV</td>
<td>108/4/10**</td>
<td>80/20 (44)**</td>
<td>275/195 (227)</td>
<td>292Δ</td>
<td>75</td>
<td>70</td>
<td></td>
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<tr>
<td>VIII</td>
<td>—</td>
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<td>—</td>
<td>—</td>
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<td>—</td>
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<tr>
<td>IX</td>
<td>60/-5/12 (26)***</td>
<td>56/25 (19)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
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<tr>
<td>X</td>
<td>36/6/16 (19)</td>
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<td>60</td>
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<td>210/175 (191)</td>
<td>112††</td>
<td>64</td>
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<tr>
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<td>57/-5/0 (—)</td>
<td>36/10 (21)</td>
<td>185/138 (163)</td>
<td>165/120 (130)</td>
<td>80</td>
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<td>—</td>
<td>85</td>
<td>—</td>
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<tr>
<td>Mean</td>
<td>56/0/8 (28)</td>
<td>46/21 (31)</td>
<td>208/147 (175)</td>
<td>216/130 (155)</td>
<td>92</td>
<td>70</td>
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</table>

@ at heart level.
() mean pressure for entire cardiac cycle.
Δ mean pressure during ejection.
* where recording of sufficient duration to show significant pressure variation, highest and lowest pressures are given.
+ 1 artefact in tracing.
** 2 artefact in tracing.
(∗) figures read from visually smoothed curve.
*** instantaneous and mean pressures consecutive but not simultaneous.
† nose lead inserted.
†† people return to barn after absence of 30 minutes.
↑ slow speed recording. Mean pressure derived using factor obtained from planimetry of nearest fast speed contours (see text).
y paroxysmal atrial tachycardia with varying atrioventricular block followed by fibrillation was apparently precipitated by the cardiac catheter.

arterial blood sampling was begun and continued at one second intervals for 36 sec.
The sample tubes contained dry heparin. The tube rack was hand-held. Additional arterial blood samples for measurement of the general blood volume were obtained at varying intervals up to 30 min. The blue-dyed plasma specimens were read undiluted on a Coleman Junior spectrophotometer at 620 mμ. The green-dyed plasma samples were of small volume and required dilution with carefully measured volumes of physiological saline solution. The dye concentration was measured on a Beckman Model B spectrophotometer at 510 mμ. Time-concentration curves were constructed from

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the values for optical density from which the plasma flow, the plasma volume, the mean circulation time and the catheter-to-needle volume or Q were calculated. The corresponding values for whole blood were derived from the hematocrit reading.

The work of the ventricles was calculated from the formula: cardiac output \times (pulmonary or carotid arterial mean pressure during ejection) \times 13.6 \times 10^{-3} \text{ kilogram meters per minute}.

Results

Intravascular Pressures

The carotid arterial mean pressures at heart level ranged widely, from a low of 84 to a high of 227 mm Hg (table 2); these mean pressures were associated respectively with systolic/diastolic pressures of 118/62 and 275/195 mm Hg. The average of the lowest mean pressures in the individual animals was 135 and of the highest mean pressures 175. The pressures tended to be higher at the time of the initial recordings and to fall with time, particularly if the number of persons in the immediate environment of the animal was reduced and if the manipulations about the animal's head and neck were discontinued. In animals III, VIII, VII and IX, in which efforts were made to minimize noxious stimuli, a progressive fall in arterial blood pressure occurred. Only one individual was in attendance on Cow III; Cows VIII, and VII were left alone for approximately 30 min. in their own barn, except for a short period when equipment was checked, and Cow IX was left alone entirely for the same period. In animal VIII, at the age of 11 months the arterial blood pressure reached relatively low levels but exhibited remarkable lability (fig. 1). Six months later in the same animal, the arterial blood pressure was considerably higher and fell less strikingly over the period of 30 min. during which the animal was unmolested. The pressure behavior in Cow IX (fig. 2) was similar to that in Cow VIII. It is interesting to note that as soon as human beings re-entered the barn, the heart rate in Cow IX rose rapidly from a level of 82 to 116 beats/min.

The range of pulmonary arterial pressures was somewhat smaller, but still considerable, the lowest mean pressure being 21 and the highest 44, associated respectively with systolic/diastolic pressure of 24/17 and 80/20 mm Hg. The highest and lowest pulmonary arterial systolic pressures were 80 and 24 respectively, and the highest and lowest pulmonary arterial diastolic pressures 27 and 10. The average of the lowest individual pulmonary arterial mean pressures was 24, and of the highest mean pressures 31 mm Hg. Pulmonary and systemic arterial pressures tended to vary in the same direction with respect to slow changes. Transitory oscillations in the carotid pressure were often associated with little or no change in pulmonary arterial pressure, and occasionally with a pulmonary arterial pressure change in the opposite direction.

Technically satisfactory tracings of pulmonary arterial and carotid pressure pulse contours (fig. 3) were obtained using PE 90 tubing. In this carotid recording the tip of the tubing was estimated to lie 10 or more
centimeters from the aorta, so that the recorded contour may have differed slightly from the central pressure pulse contour. A small spike at the termination of the anacrotic limb of the carotid pulse, a domelike systolic peak at approximately the same level, and a gradual slope of the diastolic limb following the incisura characterize this contour. The pulmonary arterial contour shows a sharper systolic peak and a lower position of the incisura on the descending limb of the systolic curve. In several instances the pulmonary arterial systolic pressure shortly before withdrawal of the catheter to the right ventricle was 6 to 10 mm. Hg lower than the ventricular systolic pressure. Convincing pulmonary capillary pressures were not obtained, presumably because the flaccidity of the polyethylene tubing did not permit of complete wedging.

Right ventricular pressures were recorded with good fidelity in Cows VIII, IX and XVII. The averages of the peak, lowest diastolic and end-diastolic pressures in these animals were respectively: highest 53, 2 and 9; lowest 30, 0 and 8 mm. Hg. These figures differed little from the mean values in 6 other animals with pressure recordings exhibiting less than 2+ artefact. Right ventricular pressure pulse contours obtained through approximately 2.5 M. of PE 90 tubing in Cow VIII (fig. 4) and through a 22 cm. no. 18 needle connected directly to the gauge in Cow XVII (fig. 5) were gratifyingly similar. The steep slope of the initial systolic limb and, immediately following the peak, the rapid falloff of systolic pressure are to be noted. Technical difficulties precluded a satisfactory electrocardiogram, but very low amplitude P, QRS and T complexes, adequate for timing purposes, can be discerned in figure 5. End-diastolic pressure is 4 to 8 mm. Hg higher than lowest diastolic pressure. Left ventricular pressure pulse contours in Cow XVII by direct puncture (fig. 6) disclosed a steeper initial upstroke, a relatively flat plateau, and absence of the end-diastolic rise seen in the right ventricular tracing. It is also of interest that the left ventricular systolic contour is in general similar to the carotid arterial pulse contour, with the important difference that a fast spike at the end of the initial upstroke is regularly seen in the peripheral arterial pulse. The maximal and mean rates of pressure rise in the initial upstroke of the left ventricular contours of Cow XVII were 2508 and 1641 mm. Hg/sec. The same figures for the right ventricular pressure contours of this animal were 660 and 527, and for Cow VIII were 437 and 280 mm. Hg/sec.

Right atrial pressure varied from 1 to 8
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mm. Hg (table 2). Within the limits of accuracy of the measurement right atrial mean pressures and right ventricular end-diastolic pressures were approximately equal. Right atrial pressure-pulse contours (fig. 7) disclosed a large wave believed to represent a combination of a and c waves. A small but readily discerned v wave, not well seen in figure 7, was present in the tracings of 2 of the 3 animals with satisfactory atrial recordings.

Cardiac Output and Related Functions

The cardiac output ranged from 28 to 52 L./min. (table 3). The stroke volume averaged slightly less than 600 ml. since the heart rates averaged about 60 beats/min. In Cow I the cardiac output determined by the Fick principle was 48.8 L./min., a reasonably good agreement with the figure obtained by the indicator-dilution method (40.9 L./min.) since the determinations were not simultaneous. The cardiac indices are double the normal human values. On the other hand, if the cardiac output be related to body weight, remarkably close correspondence with human values is found (tables 3, 4; refs. 5, 6). The agreement is somewhat better on the basis of body weight than on the basis of body weight raised to the Brody power (0.734).

The dye disappearance curves were satisfactory to inspection. The average value for the general blood volume of 63 ml./Kg. agrees well with previous observations.7 The values calculated for ventricular work are somewhat higher than those in man on the basis of body weight, since the cardiac output values are very similar per unit of body weight while the mean arterial pressures are higher in the cow. The heart of the cow, without blood in the cardiac chambers, averages about 0.5 per cent of the body weight,8 which is approximately the percentage found in man. Ventricular work per unit cardiac weight is therefore somewhat higher in the cow. As would be expected from the large values for blood flow, the calculated total vascular resistance in the pulmonary and systemic circuits is low (table 3) compared with the resistance values in smaller animals and in man.

Discussion

The remarkable lability of the arterial pressure, often with little change in the demeanor of the animal, and the wide range of pressures recorded raises the question as to what, if any, range can be considered as “normal” for bovine blood pressure. It should be emphasized that the observations reported in this paper apply only to the female of the bovine species, Bos taurus. The male was not studied because of problems imposed by the difficulty of restraint. Based on findings in other mammalian species, large differences in blood pressure between the male and female would not be expected. In the present study the cows...
# Table 3

**Blood Flows, Volumes, and Related Functions**

<table>
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<tr>
<th></th>
<th>Cardiac output</th>
<th></th>
<th>Stroke vol. mL</th>
<th>Ventricular stroke work Kg M/stroke</th>
<th>Right</th>
<th>Left</th>
<th>Ventricular minute work Kg M/min.</th>
<th>Right</th>
<th>Left</th>
<th>Total vascular resistance dynes sec em⁻²</th>
<th>Pulmonary</th>
<th>Systemic</th>
<th>A-V oxygen diff. ml/100 ml</th>
<th>Circ. time sec.</th>
<th>General blood vol. mL/Kg</th>
<th>Q L</th>
<th>ABD/V</th>
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<td>63</td>
<td>8.3</td>
<td>.33</td>
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</tr>
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</table>

q=quintals (100 Kg); BW=body weight.

Q=central blood volume; GBV=general blood volume.

* = rounded after averaging unrounded individual figures.

† = calculated from mean pressure during complete cardiac cycle.

(*) = right ventricular mean pressure during ejection phase substituted for P.A. pressure.

" = artifact in recording of P.A. pressure.

All mean pressures used in calculations determined by planimetry.
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were unused to and resented manipulations about the head and neck and usually required a nose lead for restraint. It seems a fair assumption that the lowest pressures recorded in any given animal probably corresponded more nearly to that animal's undisturbed pressure range than the higher pressures obtained. The means of these lowest systolic and diastolic values gave a pressure of 160/110, which corresponds reasonably well with the figures reported by others. Goetze, using an oscilometric technique, recorded figures for the coccygeal arterial pressure averaging 135/75 mm. Hg in 1 cow in the standing position. In the same animal in the lying position, the average pressure was 190/120 mm. Hg. Most of this difference can be accounted for by the vertical distance from the heart to the base of the tail in the standing position. Goetze also noted that the arterial pressure of the animal was very responsive to environmental stimuli and tended to fall as the animal became accustomed to the procedure. The only previously reported study of bovine arterial blood pressure by modern methods is that of Sellars and Hemingway. Direct measurements of the carotid arterial pressures in the mid-third of the neck in 105 cows yielded values of 140 to 180/90 to 130 mm. Hg. Correction to heart level, not made in these figures, would add about 20 mm. Hg. The average of the lowest systemic mean arterial pressures at heart level in these animals is obviously considerably higher than the corresponding figure for man, the difference being about 45 mm. Hg. The response of the blood pressure to complete withdrawal of human beings from the animal's environment suggests that even these lowest pressures obtained in the presence of persons are somewhat higher than the "normal" pressures in these animals. Some of the discrepancy between the pressures in the cow and in man may, therefore, have been due to anxiety, if one may apply the term to these animals. Anatomical differences between the cow and man offer a provocative avenue of speculation on another possible explanation for part of the observed pressure difference. Although the appearance of the cow suggests primarily a "horizontal" animal, the actual vertical heart to brain distance in the non-feeding animal averages approximately 30 cm. greater than this distance in man, the latter being about 34 cm. Taking into consideration the specific gravity of blood, this difference in vertical distance requires that the mean arterial pressure at heart level in the cow be 23 mm. Hg higher than in man for the arterial pressure at brain level to be the same. Hence, surprisingly, the cow in comparison to man may be regarded as a "little giraffe."

It is of considerable interest that both in the cow and in the giraffe pressure recordings from both the systemic and from the lesser circulations regularly show a fast initial spike. In the giraffe such pressure contours were recorded both with the Gauer miniature manometer and with Statham P23G strain gages. Since both of these instruments possess excellent frequency characteristics this initial spike is almost certainly not an artifact. The phenomenon is, presumably, the result of the more-or-less violent collision between blood rapidly ejected from the ventricles and the large volume of more slowly moving blood ahead of it in the lungs and in the great vessels. Similar pressure contours can be readily simulated by the brisk injection of fluid into rubber tubing moderately distended by a
Table 4
Mean Blood Flows in the Cows (Bos Taurus) and Man Related to Body Dimensions

<table>
<thead>
<tr>
<th></th>
<th>C.O. L/min.</th>
<th>C.O. L/min./q BW</th>
<th>C.O. L/min./m² (q BW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.T. (COWS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6)</td>
<td>41</td>
<td>0.9</td>
<td>6.9</td>
</tr>
<tr>
<td>MAN (8)</td>
<td>6.4</td>
<td>0.8</td>
<td>3.5</td>
</tr>
<tr>
<td>(19)†</td>
<td>6.2</td>
<td>0.3</td>
<td>3.5</td>
</tr>
</tbody>
</table>

C.O. = Cardiac output.
q = quintals (100 Kg.)
BW = Body weight.
Numbers in parentheses represent number of subjects.

* = three normal volunteer subjects ages 26-36 (ref. 6) and five "essentially" normal subject ages 26-56 (ref. 7).
† = nineteen normal and convalescent subjects without cardiopulmonary disease, ages 17-28 (ref. 8).

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Brody has shown throughout the animal kingdom the consumption of oxygen at rest is closely correlated with the body weight and slightly more closely with an exponential function of the body weight. An obvious corollary of this observation should be a similar relationship between the resting cardiac output and the body weight. This, indeed, appears to be true of both man and cow, for the minute volume per 100 kilogram body weight in the 2 species is virtually identical (table 4). On the other hand, there is a large divergence between cow and man when the cardiac output is related to body surface area, still further evidence that body surface area is not a satisfactory reference standard for metabolic functions over a wide range of body size.

Limitations in the circulatory data obtained from the giraffe do not permit extensive comparison with the present observations in the cow. A small right ventricular-pulmonary arterial systolic pressure gradient was recorded in both, a reflection, probably, of the high trans-valvular flow rate. The data available suggest that cardiac output per unit of body weight is similar in cows (Bos taurus) and in giraffe. The strikingly rapid rate of pressure rise in the left ventricle of the giraffe, in comparison with the rate of rise in the cow, suggests that this chamber has a much more forceful contraction as in the giraffe. With a single exception (Cow IV) the highest pressures in cows were lower than the lowest pressures recorded in healthy unanesthetized giraffe in the upright position. In this single exception the highest pressure was approximately the same as the lowest pressure in one of the giraffe. It was clearly demonstrated in the cow that when noxious stimuli were minimized, the arterial pressure declined strikingly. At no time in the giraffe, despite intervals of considerable duration when the animal was quiet and not subjected to manipulation, did the arterial blood pressure show a tendency to fall to any considerable degree. Indeed, hydrostatic considerations in the giraffe would presumably not permit a significant drop in perfusion pressure if cerebral blood flow were to be maintained. In the cow, the wide swings in systemic arterial pressure suggest either an excessive sensitivity to environmental stimuli or a lack of precision in vasmotor control.

A simultaneous record of pulmonary and carotid arterial pressures during phonation ("moo") is of considerable interest in this respect (fig. 8). During this maneuver, a mild Valsalva in a sense, in which a moderate volume of sound was produced, the pulmonary pressure rose 12 mm. Hg above the immediate "pre-moo" level. The carotid pressure rose a comparable amount and did not show a fall until the cessation of phonation, at the time the pulmonary arterial pressure dropped abruptly. There was no past-Valsalva overshoot of systemic arterial pressure and only minimal change in heart rate. In Cow VII, the right atrial pressure rose 22 mm. Hg during a "moo." The average heart rates obtained from the electrocardiogram before and after phonation were 90 and 65, respectively.

*In two human subjects during simulation of the "moo," intracerephalgeal pressure (balloon technique) rose 25-40 mm. Hg when a moderate volume of sound was produced, and in one human subject pulmonary arterial mean pressure (intravascular catheter rose 35 mm. Hg during the same maneuver.
during and immediately after the "moo" were respectively 94, 87 and 91 beats/min. These findings do not suggest the existence of a very sensitive baroreceptor mechanism, although an occipital sinus, thought by some to be homologue of the carotid sinus, has been described.20-24

**Summary**

Cows of the domestic bovine species Bos taurus, non-pregnant with two exceptions, exhibited a labile blood pressure, with a systemic mean arterial pressure at heart level considerably in excess of normal human pressure. The average of the lowest mean pressures recorded in each animal was 135 mm Hg. The comparable figure for the pulmonary arterial pressures was 24 mm Hg. Continuous recording of arterial pressure in 3 experiments in which human beings absented themselves from the animals' environment showed a tendency toward progressive fall of pressure, but, except for brief periods in 1 young animal, the pressures remained above human normotensive levels. It is postulated that approximately 23 mm Hg of the observed difference between systemic arterial pressure in the cow and in man represents a reflection of the greater vertical heart-to-brain distance in the cow. Thus, compared with man the cow may be regarded as a "little giraffe."

The highest systemic arterial pressures recorded in the cow at heart level were, with a single exception, lower than the lowest pressures which have been recorded in the giraffe.

Cardiac output in the cow is double that of man on the basis of surface area but is the same on the basis of body weight.

The lability of arterial blood pressure, and certain pressure and heart rate phenomena during and after the Valsalva maneuver ("moo"), suggest lack of precision in circulatory control in this species.

**Acknowledgement**

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**Summario in Interlingua**

Vacca del specie bovina domestica Bos taurus, non gravida con duo exceptiones, exhibiva un labile tension de sanguine con un tension arterial medio in le circulation major al nivello del corde considerabilemente in excesso del normal tension in humanos. Le valor medio del plus basse tensiones medio del animales individual esseva 135 mm de Hg. Le valor correspondente pro le tension pulmomo-arterial esseva 24 mm de Hg. In 3 experimentos, in le quales nulle humanos esseva presente in le ambiente del animales, continue registrationes del tension arterial monstравa le tendentia de un progressive reduction del tension, sed—con le exception de breve periodos in un animal de juventate state—le tensiones romanova supra le nivellos normotensive in humanos. Es postulate que approximativamente 23 mm de Hg del observate differentia inter le observate tensiones arterial del circulation major in le vacca e in humanos es un reflexion del plus grande distintia vertical inter le corde e le vacca.

In comparation con humanos, le vacca pote esser considerate como un micro girafa.

Le plus alte tensiones arterial del circulation major al nivello del corde esseva, con un sol exception, plus basses que le plus basse tensiones registrate in girafas.

Le rendimento cardiac del vacca es due vices illo de humanos super le base del area superficial del corpo, sed le duo es identic super le base del peso corporee.

Le labilitate del tension de sanguine arterial e certe phenomenos de tension e de frequentin cardiac durante e post le experimento de Valsalva (le "moo-moo" del vacca) suggera un manco de precision in le regulation circulatoria in iste specie.
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