Review

COMPARATIVE STATISTICAL INVESTIGATIONS REGARDING
INCIDENCE, ETIOLOGY AND TOPOGRAPHY
OF SUBACUTE BACTERIAL ENDOCARDITIS

ALEXANDER KAST

The year 1972 will be 100 years since a doctor first gave the definite diagnosis "bacterial endocarditis". At that time even Virchow himself confirmed the diagnosis in an epilogue of the editor (Heiberg, 1872). Our knowledge concerning the pathogenesis of subacute bacterial endocarditis (s.b.e.) is, however, up to this present day rather fragmentary.

During recent years, especially in the field of endocarditis, monographs have been published which are concerned with all problems of the disease in man or which present a summary of experimental studies (Anschütz, 1968; Doerr, 1970; Angrist and Oka, 1967). There is no publication, however, which deals with bacterial endocarditis from the viewpoint of comparative pathology, as has been successfully accomplished in other fields.

It is advisable therefore, to compile from the literature the results of investigations on various types of spontaneous bacterial endocarditis of domestic animals and to compare these with the values obtained in man. The incidence of the disease, its spectrum of causative organisms and the localisation in the various valve systems of the heart seem to be especially suitable for a comparative study.

INCIDENCE

Although the data of individual authors with regard to incidence of s.b.e. show considerable variations in autopsy statistics e.g. in man according to Schaub (1960) between 0.44 and 1.1%, a comparison of the percentages reveals that species with a strong fibrogenic tendency more frequently contract a polyposous bacterial endocarditis.

Thus, the result can be summarized as follows:

Dog, Man Chicken, Horse, Swine, Cattle

Also in this case the species are arranged according to the relative incidence of s.b.e., and those species which are only randomly distinguished, are joined together by underlining.

Thus, three groups are obtained:
1. Dog and Man
2. Chicken and Horse
3. Horse, Swine and Cattle

There are significant differences between these three groups. Only the horse is found in two groups. This is most probably due to the fact that the relative incidence of s.b.e. in the horse is quite frequent, and the number of animals investigated, is relatively small compared to the other species.

In Table III, besides the values observed, rank figures are given which distinguish the series in increasing order. The ranks correspond in both columns so that in the rank-correlation-analysis according to Spearman a correlation coefficient $r_s$ of 1.00 is obtained. According to the tables of Olds, this correlation coefficient is significant in 5 pairs of values, the level of error amounts to

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Key Words: Endocarditis Subacute Bacterial Comparative Investigations

(Received for publication, July 19, 1971)
TABLE I  INCIDENCE OF SUBACUTE BACTERIAL ENDOCARDITIS†

<table>
<thead>
<tr>
<th></th>
<th>Man</th>
<th>Horse</th>
<th>Cattle</th>
<th>Swine</th>
<th>Chicken</th>
<th>Dog</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autopsies</td>
<td>43939</td>
<td>1226</td>
<td>12073</td>
<td>15313</td>
<td>30755</td>
<td>9717</td>
</tr>
<tr>
<td>s.b.e.</td>
<td>716</td>
<td>29</td>
<td>412</td>
<td>487</td>
<td>607</td>
<td>141</td>
</tr>
<tr>
<td>Percentage</td>
<td>1.6</td>
<td>2.4</td>
<td>3.4</td>
<td>3.2</td>
<td>2.0</td>
<td>1.5</td>
</tr>
</tbody>
</table>

The significance test in this study was performed using a 2xR contingency table with the $x^2$ test. With these calculations, the value obtained for $x^2$ (255.9) is extremely significant. To find out between which species there are significant differences, all species are compared by pairs in 2 x-Tables. The results of these comparisons are summarized in Table II.

† For the data in Table I the autopsy statistics of the following authors have been added together: Man (Clawson, 1948; Kalman et al., 1962); Horse (Winquist, 1945), horses, which are used to produce serum excluded; Cattle (Schornagel, 1936; Winquist 1945; Evans, 1957; Biering-Sorensen, 1963); Swine (Schornagel, 1936; Bouvier, 1944; Winquist, 1945; Emser, 1956; Batis et al., 1966); Chicken (Dahme et al., 1964; Loiger et al., 1970); Dog (Schornagel, 1936; Winquist, 1945).

TABLE II  LEVEL OF ERROR IN COMPARISONS OF THE SPECIES BY PAIRS

<table>
<thead>
<tr>
<th></th>
<th>Dog</th>
<th>Man</th>
<th>Chicken</th>
<th>Horse</th>
<th>Swine</th>
<th>Cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>$&lt;0.001$</td>
<td>$&lt;0.001$</td>
<td>$&lt;0.001$</td>
<td>$0.1-0.5$</td>
<td>$0.3-0.2$</td>
<td>—</td>
</tr>
<tr>
<td>Swine</td>
<td>$&lt;0.001$</td>
<td>$&lt;0.001$</td>
<td>$&lt;0.001$</td>
<td>$0.1-0.5$</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Horse</td>
<td>$&lt;0.025$</td>
<td>$&lt;0.05$</td>
<td>$&lt;0.4-0.3$</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Chicken</td>
<td>$&lt;0.001$</td>
<td>$&lt;0.001$</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Man</td>
<td>$0.3-0.2$</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Dog</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

In Table II the species are arranged according to the relative incidence of s.b.e. The level of error is given in the "two-tailed test". If the level of error is required as a percentage, these figures are to be multiplied by 100. All comparisons marked with $<F$, are to be regarded as significant. In the "from-to-data" the level of error is greater than 5%.

0.02 or 2% in the "two-tailed test".* Thus, the relation between the incidence of subacute bacterial endocarditis in the individual species and the corresponding fibrinogen content of the blood is statistically proved.

ETIOLOGY

In Table IV the spectra of causative organisms of s.b.e. in man and in the individual species, compiled from the Literature, have been supplemented by a specific casuistry in cattle and swine and compared with one another. Unfortunately, there are no corresponding results for horse and dog. To obtain comparable values the numbers of streptococci of various serologic groups in cattle and swine have to be converted in compliance with the results of our investigations. The resulting figures only correspond to rough assessments.

Due to therapy-induced change in the spectrum of causative organisms in man from 1945, the influence of external factors on the incidence of individual pathogens, in this case e.g. pneumococci and gonococci, can clearly be seen. Also the percentage of pyogenes-endocarditis in cattle and erysipelas-endocarditis in swine in various publications are subject to extreme fluctuations.

In spite of these restrictions the special disposition of the endocardium of each species to specific pathogens can clearly be seen from Table IV. In man these are predominantly

* The biometric evaluation was carried out by Dr. F. Knappen (C. H. Boehringer Sohn, Ingelheim).
TABLE III  FIBRINOGEN CONTENT OF THE BLOOD AND INCIDENCE OF ENDOCARDITIS

<table>
<thead>
<tr>
<th>Species</th>
<th>Fibrinogen mg/100ml</th>
<th>Rank</th>
<th>s.b.e.</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man</td>
<td>280</td>
<td>2</td>
<td>1.63</td>
<td>2</td>
</tr>
<tr>
<td>Horse</td>
<td>300/340</td>
<td>3</td>
<td>2.37</td>
<td>3</td>
</tr>
<tr>
<td>Cattle</td>
<td>600</td>
<td>5</td>
<td>3.41</td>
<td>5</td>
</tr>
<tr>
<td>Swine</td>
<td>500</td>
<td>4</td>
<td>3.18</td>
<td>4</td>
</tr>
<tr>
<td>Dog</td>
<td>250</td>
<td>1</td>
<td>1.45</td>
<td>1</td>
</tr>
</tbody>
</table>

The data concerning the fibrinogen content are given according to Altman and Dittmer (1961) as well as Kolb (1962).

TABLE IV  SPECTRUM OF CAUSATIVE AGENTS OF BACTERIAL ENDOCARDITIS IN MAN AND ANIMAL

<table>
<thead>
<tr>
<th></th>
<th>n=</th>
<th>Viridans group</th>
<th>Entero cocci</th>
<th>Staphylococci</th>
<th>Pneumococci</th>
<th>Gonococci</th>
<th>Pasteurella</th>
<th>Corynebact. pyogenes</th>
<th>Erysip. rhusio.</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man</td>
<td>1890–1930</td>
<td>535</td>
<td>62%</td>
<td>13%</td>
<td>15%</td>
<td>7%</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>1944–1964</td>
<td>859</td>
<td>54%</td>
<td>7%</td>
<td>24%</td>
<td>3%</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>12%</td>
</tr>
<tr>
<td>Cattle</td>
<td></td>
<td>179</td>
<td>21%</td>
<td>7%</td>
<td>5%</td>
<td>1%</td>
<td>---</td>
<td>2%</td>
<td>43%</td>
<td>21%</td>
</tr>
<tr>
<td>Swine</td>
<td></td>
<td>356</td>
<td>5%</td>
<td>1%</td>
<td>5%</td>
<td>---</td>
<td>---</td>
<td>1%</td>
<td>84%</td>
<td>4%</td>
</tr>
<tr>
<td>Chicken</td>
<td></td>
<td>102</td>
<td>3%</td>
<td>60%</td>
<td>23%</td>
<td>---</td>
<td>---</td>
<td>6%</td>
<td>---</td>
<td>8%</td>
</tr>
</tbody>
</table>


The observations in man from 1890 to 1960, statistically show extremely significant differences from the results of 1944–1964. The differences between man, cattle, swine and chicken obtained in comparisons by pairs are also extremely significant.

streptococci of the viridans group, nowadays, however, also staphylococci are found more and more frequently. In cattle Corynebact. pyogenes are predominantly observed, followed by streptococci, also primarily belonging to the viridans group. Erysipelothrix rhusiopathiae almost seems to be the only causative agent of endocarditis in swine. Batis et al. (1966) found that among 76 cases of bacterial endocarditis in pigs there were 72 incidents of streptococci. These observations which should be taken into consideration, show that under specific environmental or immunologic conditions streptococci can also be the primary cause of endocarditis in swine. There appears to be no preference of specific serotypes. Finally, in chicken kept in an environment, enriched with intestinal flora, enterococci were found to be the principle cause of endocarditis, followed by staphylococcus aureus.

The group of other pathogens, not classified in the Table, in man primarily includes streptococci of other serotypes, gram-negative bacteria, Brucella, Rickettsia and fungi. In cattle, streptococci of various serotypes have been found, mainly necrogenic bacteria, streptococci have also been observed in swine together with Salmonella whereas in the chicken numerous E. coli have been found.

Summarizing, we can say that there is a widely scattered spectrum of causative organisms of s.b.e. The fact that this does not seem so pronounced in domestic animals than in man.

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TABLE V  LOCALIZATION OF SPONTANEOUS S.B.E. IN MAN AND ANIMAL

<table>
<thead>
<tr>
<th></th>
<th>Aorta</th>
<th>Mit.</th>
<th>Pulm.</th>
<th>Tric.</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man</td>
<td>2162</td>
<td>43%</td>
<td>80%</td>
<td>1%</td>
<td>8%</td>
</tr>
<tr>
<td>Horse</td>
<td>167</td>
<td>66%</td>
<td>31%</td>
<td>3%</td>
<td>11%</td>
</tr>
<tr>
<td>Cattle</td>
<td>46</td>
<td>16%</td>
<td>20%</td>
<td>16%</td>
<td>77%</td>
</tr>
<tr>
<td>Swine</td>
<td>232</td>
<td>36%</td>
<td>82%</td>
<td>11%</td>
<td>13%</td>
</tr>
<tr>
<td>Chicken</td>
<td>324</td>
<td>12%</td>
<td>80%</td>
<td>—</td>
<td>4%</td>
</tr>
<tr>
<td>Dog</td>
<td>85</td>
<td>36%</td>
<td>66%</td>
<td>1%</td>
<td>15%</td>
</tr>
</tbody>
</table>

The figures in Table V have been taken from the following publications, partly adding together the data which in some cases had been classified according to the pathogens: Man: Goldburgh (1942), Clawson (1948), Calabrese and Fazzini (1961), Wilson (1963), Horse: Lazitsch (1921), Weidlich (1943), Miller (1944), Winquist (1945), Wageenaar et al. (1967), Dobin (1968), Cattle: Kast (1969), Swine: Kast (1970), Chicken: Loliger et al. (1970). Dog: Lazitsch (1921), Winquist (1945), Nielsen and Nielsen (1954), Shouse and Meier (1956).

Statistically, with two exceptions, all comparisons by pairs are extremely significant (p < 0.1%). Only the two comparisons between man and dog and between swine and dog are near to the significance limit of 5%.

TABLE VI

<table>
<thead>
<tr>
<th>Localization</th>
<th>left</th>
<th>right</th>
<th>on both sides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streptococci</td>
<td>78.7%</td>
<td>5.0%</td>
<td>16.1%</td>
</tr>
<tr>
<td>Pneumococci</td>
<td>81.0%</td>
<td>8.1%</td>
<td>10.8%</td>
</tr>
<tr>
<td>Staph. aureus</td>
<td>66.6%</td>
<td>22.2%</td>
<td>11.1%</td>
</tr>
<tr>
<td>Staph. Albus</td>
<td>66.6%</td>
<td>33.3%</td>
<td>—</td>
</tr>
<tr>
<td>Gonococci</td>
<td>62.9%</td>
<td>22.2%</td>
<td>14.8%</td>
</tr>
</tbody>
</table>

might be due to the lack of specific casuistry. Principally, each bacterium might be a possible causative agent of endocarditis in each species. The incidence of individual bacilli, however, depends to a very great degree on the infective process in the species concerned, on the environment as well as on the therapeutic measures, perhaps even on the preventive vaccination. Considerable local and temporal displacements should always be taken into consideration.

**Topography**

Table V compares the localisation of spontaneous cases of endocarditis in man and animal. In each case it presents a mean value of the total spectrum of causative organisms of the species concerned. These figures immediately show considerable variations if, as in Tables VI and VII, the values for specific pathogens are given separately.

On comparing the figures in Table V, we immediately notice the special tendency of the horse towards the development of an infection of the aortic valves and the disposition of cattle towards an endocarditis of the right heart, whereas in man and the other species the mitral valve is affected far more frequently than the aortic valves. Subsequently, the pathogenic organisms show a preference to invade not only the previously rheumatic damaged mitral valve, as is generally observed in man, but also the intact bicuspid valve of most species which is particularly susceptible to bacterial invasion. In these species, the tricuspid valve, with only 10%, is the third most likely area to be attacked. An endocarditis of the opening of the pulmonalis, however, only occurs relatively seldom.

On investigating the causes for these deviations between the species, both large species, horse and cattle, show distinct differences from the other species. This suggests that specific anatomical or physiological conditions might be causes for this localisation. In reality, the systolic blood pressure values in the right ventricle of the cow, according to Grauwiler (1965) with a mean 62 mmHg, are on average about 10 mmHg higher than e.g. in the horse and twice as high as in small domestic animals. This fact alone, however, is probably not the entire cause for endocarditis in the right heart of the cow, since of course, with values up to 200 mmHg, the systolic blood pressure values in the left ventricle are always much higher.

TABLE VII  LOCALISATION OF S.B.E. IN SWINE

<table>
<thead>
<tr>
<th></th>
<th>left</th>
<th>right</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>aorta</td>
<td>mitr.</td>
</tr>
<tr>
<td>Erysipelas (206 cases)</td>
<td>75</td>
<td>177</td>
</tr>
<tr>
<td></td>
<td>36.4%</td>
<td>85.9%</td>
</tr>
<tr>
<td>Streptococci (19 cases)</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>36.8%</td>
<td>42.1%</td>
</tr>
<tr>
<td>Staphylococci (6 cases)</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>0.0%</td>
<td>83.3%</td>
</tr>
</tbody>
</table>

The purely parietal types of endocarditis occurring in a few cases only, have always been included in the adjoining valvular system.  
Kast (1970)

TABLE VIII  LOCALISATION OF S.B.E. IN CATTLE

<table>
<thead>
<tr>
<th></th>
<th>left</th>
<th>right</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>aorta</td>
<td>mitr.</td>
</tr>
<tr>
<td>Streptococci (21 cases)</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>14.3%</td>
<td>19.0%</td>
</tr>
<tr>
<td>Corynebact. pyog. (18 cases)</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>16.7%</td>
<td>22.2%</td>
</tr>
</tbody>
</table>

4 cases of Pasteurella endocarditis were localised on one occasion in both the aortic valves and the mitral valves, but on two occasions in the right heart, i.e. once in the tricuspid valve and once, in the case of an inherent abnormality, in the parietal endocardium of the right ventricle. In one case the staphylococci settled in the tricuspid valve. In cattle the parietal endocardium is frequently involved.  
Kast (1969)

The study of the findings of endocarditis in man give some indications to possible causes of localisation differences. This can be said especially in the case of acute bacterial endocarditis and in cases with inherent cardiac abnormality as previous disease.

Whereas Thayer (1931) reported the frequency of the pre-existing e. rheumatica as a total of 81.1%, the frequency of a rheumatic previous disease is only 43% with staph. aureus, 37.5% with diplococcus pneumoniae and only 14.8% with gonococci.

The following comparison was found in Thayer (Table VI).

In 62 cases of pneumococcal endocarditis, also Goldburgh (1942) observed a percentual distribution of ao. 47%, mitr. 52%, pulm. 5% and tric. 26%. For this type of pathogenic organism that would signify an increase of localisation on the right heart to 3–4 times the normal value.

From 1911–1955 Bain et al. (1958) in the Mayo Clinic tested 18 etiologically defined cases of pure types of endocarditis of the right heart and could demonstrate 11x staph. aureus, 3x diplococcus pneumoniae, 1x gonococcus, 2x sc.
viridans, 1x sc. faecalis and 1x sc. haemolyticus. The routes of treatment, 3x skin diseases and 3x infections of the respiratory tract. Dowling et al. (1952) give the distribution of 100 types of staphylococcal endocarditis in the heart, in most cases compiled from the literature, as follows: ao. = 35, mitr. = 60, pulm. = 4, tric. = 22. Hussey and Katz (1950) observed the same distribution.

Another interesting fact in this connection is the endocardial infection produced by i.v. self administration of contaminated drugs causing addiction. Thus, if heroin is contaminated with staphylococcus aureus or epidermidis, there is a highly significant predisposition of the tricuspid valve to these bacilli (Dowling et al., 1925; Bain et al., 1958; Olson and Romansky, 1961; Conway, 1969). On the other hand, with administration of opium, a mixed spectrum of pathogenic organisms (in most cases not hemolys. scc) leads to an endocarditis of the left heart (Luttgens, 1949). Manson and Samellas (1963) were the last to report on the endocarditis of the right heart belonging to the gonococcal infections of the heart, which today no longer occur so frequently.

In the 33 cases of mycotic endocarditis reported on in the paper of Merchant et al. (1958), the right heart is affected 8x (24%); it should, however, be mentioned that the parietal endocardium was by far more frequently involved than is usually the case in man.

From the viewpoint of veterinary medicine there are interesting differences with regard to the localisation of the inflammatory valvular deposits between erysipelas and coccical infections of swine (Table VII). As a rule with the streptococcal and staphylococcal infections a wider dispersion of the proliferation (granulation) can be observed on both the right and left side of the heart, and the mitral and tricuspid valves are almost as frequently inflamed. From the 19 cases of streptococcal endocarditis, 7 (37%) occur exclusively in the right heart. Conversely, erysipelas endocarditis predominantly attacks the left heart. In this case the mitral valve appears to be inflamed about 10x as frequently as the tricuspid valve and only in 9 cases (= 4.4%) the endocarditis occurs entirely in the right heart, in one case a dextroposition of the aorta being the anatomical basis for the localisation (Kast, 1970). These figures confirm the data of De Bruin (1964), who also observed an isolated endocarditis of the right heart in 15 of 23 cases of scc. endocarditis in swine, however, he observed an isolated endocarditis of the left heart in 45 of 52 cases of erysipelas endocarditis.

As far as the staphylococcal types of endocarditis in swine are concerned, only limited results are available which, however, cannot be so very reliable. Nevertheless, a certain similarity with the values for scc. endocarditis can be observed. Comparative material from the literature of veterinary medicine on this subject is as yet not available.

In cattle, however, the endocarditis of the right heart, is according to Kast (1969), not due to specific causative agents (Table VIII) since the pyogenes endocarditis also shows the same preference to attack the right ventricle as the streptococcal endocarditis. Thus, in our investigations the ratio mitral valve: tricuspid valve in the case of pyogenic infection as well as in streptococcal infection, is approximately 1 : 4. This is very much in contrast, however, to other species where for instance the comparative figures for erysipelas endocarditis of swine, according to our investigations, are mitralis: tricuspidalis = 10 : 1.

In an attempt to explain the dependence of endocardial infections, localised on the right side, on the type of causative organism, Karotkin and Marcus (1946) suggested that in the case of pneumonia the somewhat higher blood pressure of the right heart might have a favouring influence. This idea, however, explains only some of the pneumococcal and streptococcal infections. Doerr (1970) refers to the fact that the focus of infection of endocarditis of the right heart is frequently found in the abdominal cavity.

This would also account for some cases in cattle, where the focus is seen in association with the pyogenic infections in abscesses of the abdominal cavity (e.g. local peritonitis according to John, 1947) as well as in metritis or mastitis.

Various authors have discussed hepatic discomatosis in cattle (Eucken, 1929; Zwienenberg, 1933; Evans, 1957). In these papers displaced parasites are reputed to produce an endocardial lesion in the right ventricle, while hepatic abscesses caused by spreading of intestinal bacteria, constitute the focus. Individual cases of parietal endocarditis traumatically develop from a foreign-body perforation from the divisions of the fore stomach (Mussil, 1946; Diernhofer, 1946; Huhn and Muller, 1955). Even the traumatic endocarditis in cattle are localised predominantly in the right heart!

Undoubtedly the type of causative organism and its biological properties are important factors for the attachment in the right heart, and it certainly is an essential condition for the viability of the bacilli in the right heart that both Corynebacteria and streptococci grow as well in a CO₂ medium as under aerobic conditions. Whereas in the left heart of a large animal an oxygen saturation of 94% is measured, the right ventricle only shows 24.5% (Wagenaar et al., 1967). However, the facultative anaerobic bacilli among the causative agents of endocarditis in cattle, have no growth problems in the right heart.

The ability of the causative organism to thrive in an oxygen-starved environment, however, could by no means be the primary cause of endocarditis of the right heart in the cow. Perhaps the spectrum of causative agents—so far as it concerns the genus of streptococci—shows a certain similarity with man. Also in cattle about half of the streptococci causing endocarditis belong to the group of streptococcus salivarius of various biochemical types, which cannot be classified serologically, whereas sc. of other serotypes occur less frequently. In contrast to man, where endocarditis lenta produced by Sc. viridans alias salivarius is almost without exception an endocarditis of the left heart, the streptococci of the viridans group in cattle are found primarily in the right heart.

This clearly underlines the fact that in cattle, the properties of the causative agents, e.g. with regard to their oxygen requirement, are not such deciding factors in the predilection of endocarditis of the right heart as those involved in the structure of the heart itself and possibly in the coherent blood pressure values and trends of the blood circulation. If the anatomy of the cow’s heart is investigated keeping these facts in mind, malformations of the heart would first have to be taken into consideration, which in man, according to Schaub (1960), provide about 11% of the anatomical requirement for subacute bacterial endocarditis. Also in cattle, inherent valvular insufficiencies, particularly in the sense of a dextraposition of the aorta or a septal defect, which cause an increase in blood pressure in the right heart and subsequently provide the disposition for an endocarditis of the right heart, are by no means infrequent (Kast, 1970). Up to this present time, however, only very few authors (Olafsen 1939) reported on valvular defects in combination with an endocarditis, and also in our investigations among the 46 cases in cattle, only two cases of endocarditis were due to a malformation (4%). In the normal heart of the cow there are scarcely any similarities with these cardiac changes accompanied by an increase in blood pressure. In contrast to other mammals, the heart of the cow only differs insofar as there is no pars membranacea, a triangular, thin-skinned region in the dorsal part of the ventricular septum (Hahn, 1908), (Jarisch, 1911).

According to the type and localisation of the cardiac malformation and to the coherent deviation in the circulatory conditions, specific valvular insufficiencies are also connected with typically localised endocardial inflammations. Corresponding to the additional stress of both sides of the heart with open ductus botalli, approximately the same number of endocarditic processes can be detected in the left and the right heart. The a. pulmonalis and aorta lying directly in the shunt as well as the openings of the ductus and the ductus itself are most frequently affected. Due to the incidental flow of blood, turbulence, change in blood pressure and increase in volume these regions are subject to an excessive mechanical strain (Lange and Mündt, 1954). In the relatively frequent cases of Fallot’s tetralogy with its variants, even with e. lenta the valves of the right heart are primarily affected.

In man, apart from this disposition of specific causative agents and congenital cardiac abnormalities there are also distinct sex dependent differences in localisation. Calabrese and Fazzini (1961) found that 57.52% of women had a general endocarditis, whereas 71.42% had endocarditis of the right heart. In Berlin, Goerttler (1968) evaluated 1800 cases of endocarditis of all types and subsequently found a distinct sex disposition of the aortic valves in man:

- male a0. 28.4% mitr. 40.0%
- female a0. 8.8% mitr. 63.9%

In cattle, however, it is reputed that there is no subaortic stenosis as occurs in man and even more frequently in the pig, which possibly constitutes an essential cause of the more frequent endocarditis of the left heart in other species (Emsho, 1956; van Nie, 1964).

In this connection it should be mentioned that leucosis in cattle, in contrast to the findings in all other species, shows a tendency to settle in the wall of the right ventricle, possibly also a result of specific blood pressure and circulatory conditions in the right heart of the cow.

In man, endocarditis of the right heart occurs principally in children and juveniles as complica-
tion of inborn valvular insufficiencies (Barker, 1949). According to Lange and Mundt (1954), endocarditis verrucosa is almost entirely the result of inborn valvular insufficiencies, whereas the same authors estimate the incidence of s.b.e. with congenital abnormalities at 7–8%. According to Shah et al. (1966), 13.6% of children are affected by the disease at an age of 5 years, those suffering from a septal defect, contract s.b.e. up to an age of 70.

On the other hand, women have a tendency to develop endocarditis of the mitralis. According to Cates and Christie (1951), an isolated endocarditis of the aortic valves occurs 5x as frequently in male as in female patients. Unfortunately, with endocarditis of the aortic valves, we cannot draw a comparison with the horse since there are no available data on the sexes.

Thus, we can say that there are a variety of reasons for localisation differences of a bacterial endocardial infection. Whereas in individual species (man, swine) distinct connections with the type of causative agent can be detected, these factors appear to be insignificant in the endocarditis of the right heart in cattle. Since, in contrast to man, congenital valvular defects can be eliminated as the cause of infection, no explanation can at present be given for the factors causing endocarditis of the right heart in cattle.

SUMMARY
1. As far as the rank in the incidence of subacute bacterial endocarditis in man and in various domestic animals is concerned, a significant dependence on the fibrinogen content of the blood could be observed.
2. The spectrum of causative agents of s.b.e. shows extremely significant differences in species. Whereas today in man the streptococci of the viridans group with 54% occur more frequently than staphyloccoci, in cattle, Corynebact. pyogenes with 43% is superior to the streptococci of the viridans group (21%). Eighty-four per cent of s.b.e. in swine are caused by Erysipelothrix rhusiopathiae, whereas in chicken, under specific environmental conditions, enterococci with 60% appear to be superior to staphyloccoci (23%). Considerable local and temporal displacements should, however, always be taken into consideration.
3. Whereas in man and in most species the mitral valve in approximately 80% of cases is most frequently affected with bacterial endocarditis, the aortic valves (66%) in the horse and the tricuspid valve (77%) in cattle are predominantly affected. In animals, the influence of inborn cardiac abnormalities on incidence and site of s.b.e. is of no significance. Even the type of causative organism, in contrast to the conditions in man and swine, has no influence on the localisation of endocarditis in cattle in which unknown hemodynamic factors may be of significance.

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