flow through the ductus ceased, and also that severely asphyxiated babies were excluded from the study.

The murmur from the partly contracted ductus in animals is louder than any that were heard in babies. A possible reason for the difference is the elongated shape of the animal thorax with the great vessels lying closer to the chest wall. Relative pressures in the great vessels may also be of a different order. Further investigation may reveal more of the haemodynamic conditions responsible for the murmur. For the present its detection in a proportion of babies supports the idea that in the human as in the lamb the ductus conducts blood from aorta to pulmonary artery for a short but appreciable time after birth.

Summary

One hundred healthy babies were examined in the early hours of life. A distinctive murmur was heard in 37, and lasted for a short time. In its quality on auscultation, manner of conduction on the chest wall, and phonocardiographic properties it resembled the murmur present in persisting patency of the ductus arteriosus. The murmur was therefore attributed to flow from aorta to pulmonary artery through the ductus. The analogy with findings in the newborn lamb, where the ductus is partly contracted and a continuous murmur heard, is discussed. It is concluded that, in the babies examined, mild asphyxia at birth was responsible for the majority of the murmurs. The minority were related to a body temperature above average. Other murmurs that were detected in the first 24 hours of life are briefly described.

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Two new films, produced by Stanley Schofield Productions Ltd., were recently shown to the medical press. "An Introduction to the Study of Child Health" (16 mm., sound, 20 minutes), directed by Professor F. M. B. ALLEN, Nuffield professor of child health at Queen's University, Belfast, and sponsored by Cow and Gate Ltd., is intended for second-year medical students, nurses, and others. "Breast Feeding" (16 mm., sound, 25 minutes) was made at the British Hospital for Mothers and Babies at Woolwich as a tribute to the late Dr. H. K. Waller. It is intended for showing to nurses, midwives, and expectant mothers. These films may be viewed by arrangement with Stanley Schofield Productions Ltd., 6-8, Old Bond Street, London, W.1.

POST-MORTEM OBSERVATIONS ON CONTRACTION OF THE HUMAN DUCTUS ARTERIOSUS

BY

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There is now no doubt that in experimental animals the ductus arteriosus contracts actively at or about the time of the onset of respiration. The matter has been studied at Oxford by elegant and elaborate methods; several earlier papers were summarized in a brief report by Born, Dawes, Mott, and Rennick (1955). They and their colleagues made a variety of direct observations on the ductus arteriosus of the lamb. Contraction of the ductus has been observed also in the guinea-pig (Kennedy and Clark, 1941), in the dog (Everett and Johnson, 1951), and again in the lamb by Danesino, Reynolds, and Rehman (1955).

It is natural to assume that the same thing happens in the human also. The media of the human ductus arteriosus is predominantly muscular, in contrast to the largely elastic media of the pulmonary trunk and the aorta (Kennedy and Clark, 1941; Jager and Wollenman, 1942; Danesino *et al.* 1955). Lind and Wegelius (1954) have in fact observed contraction of the human ductus by angiocardiology, but observations such as those made on animals cannot be made on human subjects. It is possible, however, to observe the condition of the ductus arteriosus at post-mortem examination of stillbirths and neonates. This has been done over a period of two years at Paddington General Hospital.

Method

The method has been to remove the tongue and the thoracic viscera in one block, after removal of the thymus; then the pericardium is opened up and the aorta and the ductus and their great branches are dissected out, with special attention to clearing up the space between the ascending aorta and the ductus.

This procedure usually enables one to say with reasonable certainty whether the ductus is contracted or uncontracted, particularly when one has learnt to recognize the uncontracted state. In this condition the ductus, seen from the front, appears little narrower than the pulmonary trunk; it tapers only slightly from its origin to its entry into the aorta; and it is rather soft and flexible. On the other hand, the contracted ductus tapers more steeply from its origin to a zone of maximum contraction, which often occupies all its distal half; and it is firmer and more rigid than either the uncontracted ductus or the other great arteries. The uncontracted ductus can be compared with that seen in slightly macerated foetuses, while the contracted ductus can be likened to that of the infant of a few weeks old (see Photograph). Partial contraction and dilatation are sometimes seen, but most cases fall into the categories of "contracted" and "uncontracted."

The condition of the ductus arteriosus has been noted in 109 post-mortem examinations, consecutive except for three or four much-macerated cases. The total of 109 is reduced to 100 by the exclusion of five that were more than 28 days old, and by four that were by oversight not weighed. Among the 100 cases there were 63 neonatal deaths and 37 stillbirths. They were classified into three groups by weight: those weighing 2,500 g. (5½ lb.) or more and regarded as mature, those weighing less than 2,500 g. but

Four sets of great vessels, seen from the front. The aorta and pulmonary trunk have been cut across just above the valves, the pulmonary arteries close to the lungs, and the descending aorta about 1 cm. below the entry of the ductus arteriosus; the arteries arising from the arch of the aorta have been cut across 3 or 4 mm. above their origins. (Same size.) Top left, from a slightly macerated stillborn infant weighing 2,370 g.; ductus uncontracted. Top right, from a stillborn infant weighing 3,490 g., not macerated; ductus uncontracted. Bottom left, from an infant weighing 2,935 g., dying 12 hours after birth; ductus contracted. Bottom right, from an infant weighing 4,790 g., dying at the age of 3 months; ductus not much narrower than the foregoing.

more than 1,250 g., and those weighing less than 1,250 g. The condition of the ductus arteriosus was recorded as contracted, partly contracted, uncontracted, or dilated.

Results and Discussion

The results are set out in the accompanying Table. We see that among 63 infants who had lived independently the ductus was contracted in 46 and uncontracted in 11. On

Results in 100 Cases

State of Ductus	Over 2,500 g.	1,250-2,500 g.	Under 1,250 g.	Total
<i>Neonatal Deaths</i>				
Contracted	6	22	18	46
Partly contracted	1	2	2	5
Uncontracted	6	3	2	11
Dilated	—	—	1	1
Total	13	27	23	63
<i>Stillbirths</i>				
Contracted	1	1	—	2
Partly contracted	5	3	—	8
Uncontracted	16	8	1	25
Dilated	—	1	—	1
Total	22	13	2	37

the other hand, among the 37 stillborn infants, the ductus was contracted in only 3 and uncontracted in 25. The findings in the neonates and stillbirths are complementary, and support the proposition that the ductus arteriosus contracts in relation to the onset of respiration. (Statistically the correlation is highly significant; $\chi^2 = 37.67$, and $P < 0.001$.)

It may at first sight seem inconsistent that among the neonatal deaths were some cases in which the ductus was uncontracted or only partly contracted. But the ductus has been observed to contract or dilate with varying conditions of oxygenation (Born *et al.*, 1955), and repeated contractions have been observed by Lind and Wegelius (1954). So the cases here mentioned are not necessarily inconsistent, but may in fact support the idea of contraction.

Similarly the observation of partial or complete contraction of the ductus in stillbirths may signify that in these

cases the mechanism for initiating respiration had for some reason been set in action too soon. (In the small number of cases so far seen there is no indication that protracted labour has anything to do with it.) Or it might be that respiration had been initiated at the correct time, but the infant had died soon after from some other cause. But these are speculations. Perhaps further study of clinical correlations will produce something more substantial.

The Table shows one or two other interesting points. First is the rather unexpected observation that 50 of the 63 neonatal deaths were cases of prematurity, while 22 of the 37 stillbirths were mature. One would be inclined to expect that stillbirth would be more common in premature than in mature infants, on the assumption that the mechanism for starting respiration would not be so well developed in the premature infants as in the mature ones. But in this group of cases the reverse appears to be true, for of the 46 cases of neonatal death with contracted ductus no fewer than 40 were premature, and 18 of the 40 infants weighed less than 1,250 g. Indeed, the most striking appearance of contraction of the ductus arteriosus is to be found in the more premature infants. On the other hand, of 11 cases of neonatal death with uncontracted ductus, 6 were mature.

Among the 25 cases of stillbirth with uncontracted ductus 16 were mature, and only one weighed less than 1,250 g. There were only three stillbirths with contracted ductus out of the total of 37.

It will be noted that there appears to be a concentration of uncontracted ductus among the mature infants (22 out of 35 mature infants had uncontracted ductus; 22 out of 36 examples of uncontracted ductus were in mature infants). Some of the stillborn infants are known to have had their hearts beating up to a few minutes before delivery, and some of them briefly after delivery. The apparent association between stillbirth, maturity, and uncontracted ductus raises the question whether the onset of respiration may sometimes be inhibited by foetal or maternal factors not yet recognized. Here, too, further study of clinical correlations may prove useful.

Of the 63 neonatal deaths, 26 infants died on the first day; in these 26 the ductus was contracted in 15, uncontracted in 9, and partly contracted in 2. Of the 14 infants dying on the second day, the ductus was contracted in 10, uncontracted in 2, partly contracted in 1, and dilated in 1. Partial contraction has been observed once in an infant dying on the third day, and once in an infant dying on the fourth. An uncontracted ductus was observed in an infant dying on the fourth day; otherwise than this, none was seen later than the second day.

A word should be said about the patency of the contracted ductus as here described. All these cases would without doubt be patent to a probe, in the sense that a larger or smaller probe could be pushed through more or less easily. Correspondingly, it may well be supposed that a certain amount of blood might flow through in either direction, and perhaps cause murmurs, as observed in the lamb by Dawes and his colleagues. The use of a probe in a more critical fashion, as reported by Mitchell (1957), provides results broadly compatible with those of the present report.

No attempt has been made to study the histology of the ductus arteriosus, as it has been done in great detail already (Jager and Wollenman, 1942; Danesino *et al.*, 1955). However, a few histological preparations have been made; and it may be said that the appearance of the contracted human ductus in transverse section is very much what would be expected, and resembles that of the guinea-pig illustrated by Kennedy and Clark (1941).

Noback and Rehman (1941) examined embalmed infants encased in wax to preserve spatial relationships, and made the rather surprising report that the ductus arteriosus enters the aorta on its antero-lateral aspect about 1 cm. distal to the origin of the left subclavian artery. I have confirmed this on several occasions by simply removing the heart and

lungs and dissecting away the pericardium, leaving the aorta and pulmonary trunk undisturbed except for cutting them across just above the valves. When this has been done the ductus can be seen to cross the descending aorta from right to left at a very acute angle and enter it, as described, on its antero-lateral aspect. When the vessels are removed from the body their elasticity abolishes this relationship.

Summary

Post-mortem observations show that the ductus arteriosus may be contracted or uncontracted. In most infants that have lived independently it is contracted, while in most stillborn infants it is uncontracted. These observations are taken to support the idea that active contraction of the ductus is associated with the onset of respiration.

Most of the stillborn infants were mature, and most of the neonatal deaths were of premature infants. In both stillbirth and neonatal death there were more examples of uncontracted ductus among mature infants than among premature infants. The questions inherent in these findings require further study.

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AN OUTBREAK OF POST-OPERATIVE SEPSIS

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Outbreaks of post-operative sepsis are not uncommon, and many have been reported (Devenish and Miles, 1939; Sevvitt, 1949; Blowers, Mason, Wallace, and Walton, 1955; Shooter, Taylor, Ellis, and Ross, 1956; Shooter, Griffiths, Cook, and Williams, 1957). A recent outbreak at Guy's Hospital followed a common pattern, but the evidence which suggested the probable route of cross-infection was unusually clear-cut. The details of the investigation and findings are presented in the hope that they may suggest means of preventing further outbreaks of this kind.

In February, 1957, two surgeons, Mr. A and Mr. B, noted an increase in the incidence of post-operative sepsis among their patients. Their impression was that, although they and their registrars operated elsewhere, sepsis occurred only among those patients whose operations were performed in one particular theatre at Guy's Hospital (theatre 3). This theatre was also used

by other surgeons, but they had not noticed any trouble. It was thought that ward cross-infection was unlikely, because the wards were shared with other surgeons whose patients were not infected. In view of this information we decided to concentrate attention on one particular operating theatre, and accordingly samples were collected from a variety of sources to see whether a possible pathogen could be identified.

Chronological Account of Main Events

On Thursday, February 14, settle plates were exposed, samples of air were taken, and furniture and fittings were swabbed during Mr. A's operating session. Pieces of suture material were taken for culture from the sterile suture trolley.

By the next day it was apparent that one piece of "terylene" suture material was infected with a Gram-positive coccus and that staphylococci had been cultured from the samples of air and from swabs of fixtures. The organism infecting the terylene suture proved to be *Staphylococcus pyogenes*. It was known that Patient D had been ligated and his wound sutured with this material. It was at once thought that the terylene sutures had escaped sterilization. Samples of suture were taken from theatre stocks and cultured. Further samples were taken after having been autoclaved in the customary manner. Neither the samples taken before autoclaving nor those taken after autoclaving were found to be infected with *Staph. pyogenes*. However, the sterilization process was not perfect, as the cultures of three of the samples of autoclaved suture grew a saprophytic actinomyces after prolonged incubation.

Nose and throat swabs were taken from all nursing staff working in theatres, the theatre orderlies, Mr. A, his registrar and house-surgeon, and the medical students on Mr. A's firm. Staphylococci were found in the nose of some of these and in the throat of one nurse. Patient D had now developed signs of wound sepsis and soon discharged pus from which *Staph. pyogenes* was cultured.

This was the state of affairs by Monday, February 18, when Mr. A again operated. Further samples of terylene suture material were taken from the suture trolley, but in view of what had happened previously none was used on the patient (Patient J).

Several of the staff with staphylococci in their noses could have infected patients previously under Mr. A's care, especially the registrar and the scrub nurse (Nurse X). The registrar knew himself to be a nasal carrier of staphylococci, but had not had any post-operative sepsis among patients upon whom he had operated in theatres other than theatre 3. Nurse X had started work in the theatre the previous December and the outbreak started in January. She always scrubbed for Mr. A. and Mr. B. In view of this strong circumstantial evidence she was withdrawn from the operating theatres. As an additional precaution all the nasal carriers among the nursing staff were temporarily suspended, as were the medical students until the results of phage-typing were known.

Patient J developed post-operative sepsis and discharged pus. The terylene suture material collected on the occasion of his operation but not used in him was found to contain staphylococci.

The staphylococci cultured from Patients D and J, Nurse X, and the suture material were all of the same phage type, which was different from the phage type of the rest. A staphylococcus cultured from a settle-plate placed near the scrub nurse on February 14 also proved to be of the same phage type. These strains were penicillin-resistant but sensitive to streptomycin, chloramphenicol, erythromycin, tetracycline, and novobiocin. No further case of sepsis occurred after Nurse X was withdrawn.

Nurse X was not allowed to return to work in the theatres and the outbreak ceased.

The investigation tended to centre in Mr. A's firm, but as further information was collected it was found that two