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sténose mitrale reçut sa meilleure démonstration par la phonocardiographie.

Les auteurs expliquent la singularité des signes auscultatoires chez ces malades par la rotation du cœur et le déplacement de la zone de projection de la valvule mitrale vers la gauche. Ils croient que dans un certain nombre de mitraux la présence d'un souffle systolique apical ne peut s'expliquer ni par un reflux mitral ni par calcification de la valvule mitrale ni par insuffisance tricuspidienne.

Ils prétendent que le souffle systolique dans ces cas dépend d'une anomalie hémodynamique encore inexpliquée, et suggèrent que chez des malades qui ne présentent qu'un souffle systolique à la pointe, ce signe proviendrait d'une sténose fonctionnelle de l'artère pulmonaire.

SUDDEN UNEXPECTED DEATH IN INFANTS*

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"And this woman's child died in the night; because she overlaid it." 1 Kings, 3:19.

IT HAS BEEN KNOWN since biblical times that apparently healthy infants may die suddenly for no obvious reason. The pathological changes found in these infants were thought to be produced by asphyxia but the cause of this could not be found and it was then assumed that death was due to accidental suffocation. This assumption is unsatisfactory as there is no direct evidence for it and it implies that the parents have been neglectful.[1] Recently it has been suggested that some of these infant deaths are due to infection, because microscopic inflammatory changes are often found at autopsy.[2] The way in which infection causes death and the reasons why there are no preceding signs of ill-health are not explained.

This paper is an account of the pathological changes found in 12 infants who died suddenly for no obvious reason. These changes are compared with the effects of acute asphyxia produced experimentally in rats.

AUTOPSY FINDINGS

Autopsies were performed on 12 infants who died suddenly and unexpectedly between January 1957 and April 1958. The usual history was that the infant was put to bed at night apparently well and was found dead when next seen by the parents. The shortest interval between the infant's being put to bed and found dead was 15 minutes. Ten of these infants were boys and two were girls. All were less than six months old and the mean age was nine weeks. At autopsy the principal changes were in the intrathoracic organs. In all infants there were petechial hæmorrhages in the lungs, heart or thymus. The lungs were congested, and pink frothy fluid could be expressed from them. No internal obstruction of the respiratory airway was found in any of the 12 infants. In nine the larynx was examined with particular care and no gross abnormalities were seen. Microscopically the lungs were congested and œdematous and contained subpleural petechial hæmorrhages. An accumulation of inflammatory cells was found in the lungs of only two infants. The larynges of nine infants were examined microscopically and in each there was minimal congestion and œdema. The laryngeal mucous glands were distended with secretion, and in the tissue around the laryngeal ventricles there were some scattered plasma cells and occasional neutrophils. No constant bacterial flora was isolated from cultures of the heart blood or lungs. Cell-free extracts of the larynges of two infants and the lungs of nine were added to tissue cultures, and no cytopathogenic agents were detected.

RAT EXPERIMENTS

Acute asphyxia was produced in 20 anæsthetized white male rats by sudden occlusion of an intratracheal cannula. The rats weighed from 220 to 490 g. Anæsthesia was induced in each with ether and maintained with sodium pentobarbital (Nembutal), 30 mg./kg. intraperitoneally. A glass cannula was inserted into the trachea of each rat through a midline incision in the neck. On this cannula there was a stopcock which could be turned to block the airway. Continuous records of the rats' intra-œsophageal pressures were obtained through a saline-filled polyethylene tube 1 mm. internal diameter connected to a Sanborn electromanometer. The tube was inserted through the rat's mouth until its tip was in the midthoracic region. The records indicate intrathoracic pressure changes before and after obstruction of the airway.

When the airway was suddenly blocked, respiratory movements became slow and forceful for 15 to 35 seconds. Then attempts to breathe ceased and there was complete apnœa for about 70 seconds. This apnœa persisted even if the airway was opened by turning the stopcock, but respiratory movements could be initiated again by giving artificial respiration for a few seconds. If this was not done, gasping respiratory movements occurred 1½ to 2 minutes after the airway was initially closed. Sometimes the gasps were weak and even though the airway remained open the rats died (Fig. 1). In rats which recovered, crepitant rales could be heard in the lungs, and sometimes pink froth appeared in the cannula.

Autopsies were performed on the rats, and intrathoracic petechial hæmorrhages were constantly found. There was also pulmonary congestion and some œdema. These changes resemble those found in the infants described above, though in the rats the pulmonary œdema was less prominent.

DISCUSSION

A number of causes may contribute to sudden unexpected death in infancy, but the manner of death and the autopsy findings are always remarkably similar. The appearances of the dead bodies are those which have been associated for thousands

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of years with respiratory obstruction and which may be simulated in rats by blocking the airway. The principal difficulty in accepting respiratory obstruction as the mechanism of sudden unexpected death in infancy is that usually there is no evident cause for it; very occasionally there is glottic œdema but inflammatory changes are ordinarily quite minimal.

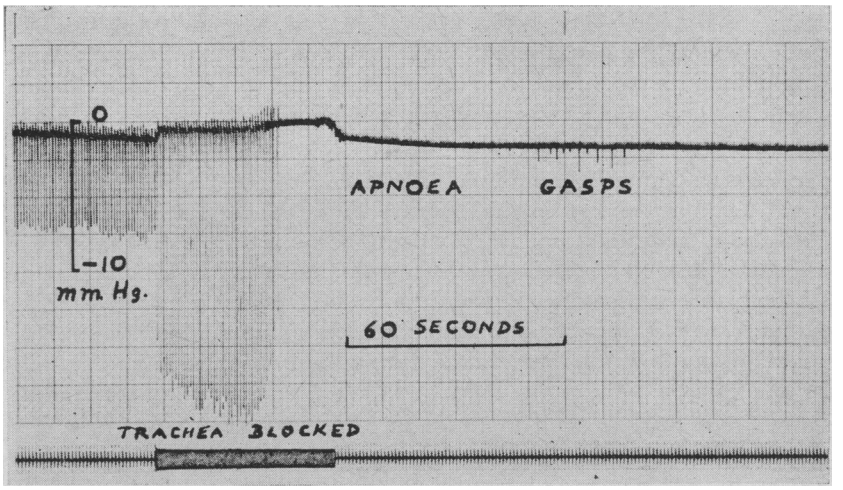

Fig. 1.—Intra-œsophageal pressure changes and temporary obstruction of the airway. Inspiration is recorded as a downward movement. The airway was blocked for 50 seconds and then opened. Gasping respirations followed a period of apnœa, and even though the airway was then open the rat died.

These minimal inflammatory changes, usually in the upper respiratory tract, appear to be the only basis for the widely held belief that such deaths are due to overwhelming infection.[3] This explanation is unsatisfactory in that the inflammatory changes are not marked and they are so localized. The theory offers no explanation for the suddenness of death, and is much weakened by the failure of all attempts to recover pathogenic micro-organisms from the blood.

The experiments on rats described above show that temporary respiratory obstruction in these animals can produce fatal apnœa. Respiratory arrest produced in this way might be the mechanism of sudden unexpected death in infants, and the obstruction could well be due to spasm of the larynx in the presence of only local and minimal inflammation. Infectious croup or laryngospasm has a sex, age and seasonal incidence closely corresponding to the incidence of sudden unexpected death.[4] Bronchitis and bronchiolitis are also accepted causes of temporary respiratory obstruction and might produce death by a similar mechanism. Obstruction by spasm has not previously been considered an adequate explanation of these deaths, because it is thought that such spasm ordinarily relaxes before respiratory movements cease. This is generally true in adults, but it is possible that in some infants temporary obstruction due to spasm may cause irreversible and fatal apnœa. An acute and early upper respiratory infection in infants might then cause death by producing spasm of the larynx and fatal apnœa; at autopsy there would be the changes in the intrathoracic organs generally associated with respiratory obstruction, together with minimal inflammatory changes in the larynx.

This theory has the further advantage that it would explain the similarity between the autopsy findings in infants who probably had respiratory infections and the findings in infants dying suddenly with some evidence that obstruction to respiration was external, as by pillows and bed clothes or even by overlaying.

SUMMARY

A description has been given of the pathological changes found in 12 infants who died suddenly and unexpectedly, and these changes have been compared with the effects of acute asphyxia produced experimentally in rats. It has been shown that it is possible to produce fatal respiratory arrest in rats by temporarily blocking the airway. It is suggested that respiratory arrest produced in this way may cause sudden death in infancy, and that the temporary obstruction may be laryngospasm or bronchospasm due to infection.

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RÉSUMÉ

La mort subite de nourrissons, sans cause apparente, est reconnue depuis les temps bibliques. On a attribué la mort à l'asphyxie dans ces cas sans toutefois offrir de preuves satisfaisantes. Récemment la théorie de l'infection fut suggérée après qu'on eut trouvé chez ces enfants à l'autopsie des signes microscopiques d'inflammation; cependant l'intensité de cette prétendue infection ne correspond ni à la rapidité de son développement ni à la gravité de ses répercussions.

Le présent rapport est basé sur les constatations histopathologiques faites chez 12 nourrissons apparemment en santé et morts subitement. Les lésions observées furent comparées à celles que produit une asphyxie aiguë chez le rat. On trouva des pétéchies dans les poumons, le cœur et le thymus. Un liquide rosé et spumeux pouvait être exprimé des poumons congestionnés. Aucune cause d'obstruction respiratoire ne fut décelée. A l'examen microscopique on trouva des cellules inflammatoires dans deux cas seulement; aucun agent cyto-pathogène ne fut isolé et aucune flore bactérienne constante ne fut obtenue de la culture du sang cardiaque et pulmonaire. Des lésions semblables furent trouvées chez les animaux asphyxiés.

L'auteur opte pour la théorie du laryngo-spasme dont la fréquence pour l'âge, le sexe et la saison correspond à celle des morts subites des nourrissons. Une infection aiguë des voies respiratoires supérieures à ses débuts pourrait déclencher le spasme et provoquer une apnée fatale.