

maintained on cytotoxic drugs, steroids and other forms of immuno-suppressive therapy. This is another reason why the zoonoses deserve our attention.

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## Salmonellosis

**Dr A. B. Christie, M.D., D.P.H., D.C.H. (Consultant in infectious disease)**

Saturday 26 June was a hot and balmy day. That afternoon a tennis tournament was held in one of the select areas of the city, and on Sunday the 27th, many of those who attended had diarrhoea and vomiting, quite a number being admitted to hospital. At the end of the week another batch of patients was admitted, many of whom were suffering from a severe pyrexial illness with or without gastrointestinal symptoms. *Salmonella virchow* was isolated from the faeces of all the patients and from the blood of nearly all those from whom a sample was taken.

At the tournament, chicken had been served both for tea and for late supper. This had been spit-roasted in a Liverpool cook shop earlier in the day and had been stored in a basket in the tennis pavilion from 2.00 p.m. onwards. As I have said, it was a very warm day and I was able clinically to distinguish those who had chicken for tea only

and those who had it for supper as well. Investigations showed that the chicken was contaminated with *S. virchow*; this organism was isolated at many points in the cook shop, and also from prawn cocktails prepared there. The hygiene of the shop was very poor. The chickens had been obtained deep frozen from a poultry plant in Cheshire. Swabs taken at various points in the plant were positive as were specimens from birds in the deep freeze. The farms supplying the poultry plant were also shown to be heavily infected, even in the hatcheries and the breeding stock. The organism was isolated from some samples of feeding stuff but it was impossible to say whether these were the source of the infection or whether the pellets had been contaminated from the atmosphere of the feeding sheds.

My colleague Dr Laing Brown in Stoke told me later that some of the frozen birds were sold in Newcastle-under-Lyme and that he still has under his care a patient suffering from severe septicaemia. Dr Kinsey of south Caernarvonshire told me that some of the chickens were sold in Portmadoc and Pwllheli; one of the customers who became ill lived on a farm with a septic tank drainage, leakage occurred, and *Salmonella virchow* was recovered from the soil of the pasture land on which some very fine specimens of Welsh black cattle were grazing. I doubt if we have heard the end of this incident, which illustrates the chain of infection in salmonellosis. Points of importance are the widespread infection, deep freezing and insufficient thawing before cooking, inadequate cooking in a spit rotisserie, and bad storage after cooking.

Salmonella infection is very prevalent in animals and the organism can readily spread to man. The normal habitat of salmonellae is the intestinal canal of one of a large number of hosts; they have for example been isolated from the intestines of pythons, skunks, elephants, seals and foxes; they have quite often been found in the faeces of pet tortoises and I have recently treated a family for salmonella infection which appears to have been caught from a pair of pet terrapins. The pigeons in Trafalgar Square are one of the sights of London but it is not commonly known that these birds are often heavily infected with salmonellae. In a recent investigation, they were isolated from 26 per cent of the pigeons in West Kensington, and from 14 per cent of those in Central London, whereas in Poplar only four per cent of the pigeons were infected, while those in Lambeth and Bethnal Green were free from infection. This might suggest that the pigeons in east and south London have as little intercourse with the birds in the west as have their human counterparts. But a more sober deduction might be that there is at present a salmonella epizootic in Kensington pigeons which has already reached Westminster and may be spreading across the metropolis.

Salmonellae are ubiquitous as regards both territory and host. *Salmonella kentucky*, for example, has been isolated from chickens and camels. *Salmonella typhimurium* which is a common human pathogen has also been isolated from the spleen of a skunk. *Salmonella vancouver* has been isolated from a solitary human infection in Canada and from coconut in Ceylon. *Salmonella choleraesuis*, a common parasite of the pig, has been isolated from the mesenteric nodes of a monkey. *Salmonella oranienburg*, an occasional cause of food poison outbreaks in man, also affects quails. On the other hand, a salmonella may have such a restricted distribution in nature that its isolation from a clinical case points at once to the source of infection. For instance, *Salmonella irumu* is largely restricted to South Africa. When it was isolated from patients in a Lancashire town who had eaten some ox heart, investigation soon showed that the food handler who sold the cooked heart was also infected with *Salmonella irumu*; moreover he handled South African frozen eggs in which the organism was present. Though the outbreak was in Lancashire, the source was in South Africa. There are many similar examples. Journeyings over such vast distances probably derive far more from the complexities of modern commerce than from any epidemiological restlessness on the part of salmonellae, but adaptability to a variety of environments seems to be character-

istic of most members of the family. An important point about salmonellae is their resistance; they are easily killed by quite gentle heat, at 62°C for 20 minutes. If you roast a joint with a lot of salmonellae on the outside, which is a common occurrence, they are quickly killed. If you are dealing with rolled rib roast, then the salmonellae that were originally on the outside get inside and penetration of heat might not be so effective. Eggs are often contaminated with salmonellae, but the temperature at which egg coagulates, 72°C, is well above the lethal temperature for salmonellae, and therefore salmonellae do not survive baking processes, though cakes may be re-infected by contaminated dust in the bakery.

One of the biggest reservoirs of salmonellae known to us is poultry and in view of the crowded conditions under which poultry are sometimes kept, this is hardly surprising. Hens always lay their eggs in dry conditions, whereas ducks lay in puddles and anywhere out in the open. When the egg is laid it is moist and warm; as it cools, a vacuum tends to be produced inside for a short time, and that vacuum can suck anything into the egg including contaminated water; if there are salmonellae in the water, they could be sucked in too. This is one reason why duck eggs tend to be infected more often than hen eggs.

The typhoid fever outbreak in Aberdeen in 1964 came about in a similar way, only this time a can of corned beef was responsible. The can was sterilized by heat, and it was cooled in water drawn from a river in South America. This water was not treated with chlorine and unfortunately it was contaminated with *Salmonella typhi*. As in the case of the duck egg, a vacuum formed while the can was cooling and a minute drop of water must have been sucked inside.

Epidemiology is the study of crowd diseases, often of crowds on the move, and the histories of expeditions, migrations, wars and pilgrimages rarely lack accounts of diseases that broke out when people left their normal haunts and encountered the make-shifts and discomforts of travelling rough. Animals in their final pilgrimage meet with similar hazards. Veterinarians are familiar with this process whereby infection increases on the move; they usually refer to it as stress. Farmers, who are also familiar with the phenomenon, refer to it as shrinkage because the animals lose condition on the way.

The conditions under which the animals travel must have a marked effect on the spread of infection among them—if they suffer from stress they become more liable to contract any infection that may be present. They may be crowded in trucks or packed tightly on board ship. Infection then spreads rapidly. In the laboratory, guinea-pigs have been infected experimentally with salmonellae by the conjunctival route, and it is possible that the same thing may happen in a cattle truck or on board a cattle ship. In the lairs at markets or abattoirs, crowding may again occur, and the rise in infection among the animals can be high. It varies with the length of time the animals are kept in the lairs; in short-stay lairs it may be around 33 per cent and in long-stay lairs as much as 80 per cent. It is now illegal to hold animals in abattoir lairs longer than 72 hours but that can be much too long if conditions are unsatisfactory. The same regulations now prohibit the use of a cloth for wiping carcasses after slaughter in the abattoir—previously such a cloth used again and again could be an effective method of spreading infection.

The amount of infection in an abattoir varies with the types of animal being killed. If there is a large number of cattle in the kill, the amount of infection is high. Sheep tend to be relatively free of salmonellae, possible because they live more out in the open and are less confined than cattle.

After slaughter, contamination of carcasses may continue. In food factories there may be unawareness of this danger, and meat may be handled with little regard to hygiene. Salmonellae on the surface of meat that is going to be roasted may not matter,

but when that meat is minced and made into sausages, the salmonellae are then present in the centre of the sausages and the heat of gentle frying may not penetrate enough to kill the organisms. It is of no avail to wrap sausages in cellophane if the meat they contain is already contaminated with germs.

The same factors affect the wholesomeness of pies. The mincemeat may be infected, and heat penetration, especially if there are cool spots in the oven, may not be enough to sterilize it. In one pie factory there was a magnificent oven which incorporated a cooling chamber to cool the cooked pies rapidly, an excellent hygienic procedure, but after the pies were taken out, agar jelly was injected into them, the 'goodness' of the pie, but the injecting apparatus could not possibly be sterilized, so that the benefit of the expensive oven was largely lost.

One of the main dangers in food shops is where raw and cooked food are handled on the same counter. Salmonellae on the surface of the raw meat may easily be transferred to the cooked meat on hands, knives, weighing machines, slicing machines, or or from the surface of the counter itself. The organisms conveyed to the cooked meat would then be able to multiply readily and as no further cooking is involved, the person who eats it may get a heavy dose of salmonellae. Poultry should not be handled near cooked food, and should certainly not be eviscerated in the same room, for then the danger of cross-contamination is very high. A wooden table can be a dangerous piece of equipment in a food-shop, for it is usually full of cracks and crevices, and salmonellae and other organisms can settle down in these cracks with an ample supply of food from dust and meat particles. Wood should be used only for chopping blocks, and these blocks should be planed down frequently.

There are many hazards between the farm and the dining table. Most of these can be avoided by awareness of the dangers and care in avoiding them.

## Toxoplasmosis

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The *toxoplasma* is biologically quite different from any of the other pathogenic organisms being discussed this afternoon. It is a parasitic protozoon, and such organisms necessarily live out their life cycle in very close association with a host. Protozoa are at once biologically more complex than bacteria or viruses; the process of evolution having produced parasites which are very well adapted to the environment of their normal hosts. And the better the adaptation, the less often will they give rise to florid disease in the host. This is the picture we find in toxoplasmosis. Many animals including man are affected but the incidence of disease is relatively low. However, it does occur both in man and animals; the unravelling and recognition of the processes involved has been slow, and probably remains unfinished.

*Toxoplasma* is a ubiquitous parasite of great versatility. It appears to be of world-wide distribution. Its success as a parasite is in some measure due to its ability to live and multiply within the nucleated cells of so many different species. Birds, as well as man and a great variety of other animals, are all potential hosts for this parasite and all occasionally fall victim to it.

The parasite exists in two forms, proliferative (trophozoite) and cystic. The trophozoite is a small crescent-shaped organism about six microns by two microns, pointed at one end and blunt at the other. It has a highly developed internal structure, and can