Chapter

Diagnosis and Identification of Zoonotic Diseases Associated with Cattle at Abattoirs: Current Trends and Future Prospectus

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Abstract

Zoonoses are illnesses and infections that spread spontaneously from animals to people. They account for over 70% of recently developing infectious illnesses. Meat from cattle is one of the main sources of red meat and essential element of human diet. Meat inspection (MI) is an important aspect to ensure the safety during handling and consuming of meat and meat by-products. Abattoir or modern slaughterhouse is the place where infections are acquired by the workers or veterinary professional as zoonoses. Bacterial zoonotic diseases such as erysipelothricosis, brucella, listeria, and anthrax and viral zoonotic diseases like cow pox, foot and mouth disease, and rift valley fever are causing great economic losses and are important in terms of zoonoses. These zoonotic diseases are mostly diagnosed at abattoir levels using conventional approaches; however, diagnosis and identification of these diseases using latest methods is an important aspect for ensuring meat safety and hygiene. This chapter will discuss the current trends and future prospects about diagnosis and identification of these zoonotic diseases.

Keywords: zoonotic diseases, cattle diseases, meat inspection, human health

1. Introduction

Zoonoses are illnesses that spread spontaneously from vertebrate animals to humans and vice versa [1–3]. Many farm animal species can transmit various zoonotic diseases in the livestock industry. Zoonotic diseases are typically present in killed animals, raw hides/skin, blood, meat, and farm surroundings in the beef industry, but they can be challenging to identify. Additionally, livestock transported for slaughter into metropolitan areas originates from rural communities with ineffective, disorganized, and frequently nonexistent disease control programs. Remoteness, limited infrastructure, a shortage of experienced veterinary staff, poor transportation, and a lack of funding to support surveillance activities or buy reagents and drugs all contribute to the low quality of animal healthcare services in rural areas. Due to the scarcity of veterinary services, there is a significant risk of widespread sickness in the livestock population and concurrent human exposure to zoonotic disease agents in these areas. Additionally, many of the butchered animals brought to the abattoir run the danger of harboring chronic or subclinical illnesses that are infrequently found during a standard antemortem inspection (AMI).

A lack of knowledge about meat-borne zoonoses can endanger the lives of livestock owners, butchers, and public. There is an even greater risk of meat-borne zoonoses in this facility, given that most home slaughter slabs and abattoirs are not fully controlled and that there is a higher level of interaction with raw meat. The dangers posed by meat-borne zoonoses that are common in certain regions must be clear to cattle owners, dealers, butchers, and policymakers. The information presented should describe how zoonoses are spread to empower persons at risk to decide how to protect themselves best [4, 5]. Many bacterial and viral diseases are frequently seen and described in abattoirs [6, 7].

One of the biggest threats to the security of the world's health is the introduction of novel zoonotic viruses. Our ability to identify and respond to these health concerns more quickly than ever before has been revolutionized by the introduction of increasingly powerful diagnostic techniques. Even yet, the initial detection of new infectious illnesses starts at the local community level, regardless of how advanced these tools have become. Here is where the original human or animal case is located, and early pathogen detection would be most helpful. Unfortunately, many regions with the highest risk of zoonotic disease introduction need to be equipped with a strong enough infrastructure to support laboratory diagnostic systems. Understanding the complex sociological and ecological factors influencing the risk of disease transmission, community involvement, surveillance along high-risk human-animal interfaces, and a skilled laboratory workforce are just a few of the factors crucial for pathogen detection networks. The growing disease paradigm, current technical developments in diagnostic techniques, and plans for comprehensive and long-term methods of quick zoonotic disease detection are all covered in this chapter.

2. Methodology

In many developing countries, disease identification and diagnosis at abattoirs is compromised and a major concern of the meat industry. Bacterial zoonotic diseases such as erysipelothricosis, brucella, listeria, and anthrax and viral zoonotic diseases like cow pox, foot and mouth disease, and rift valley fever are causing great economic losses and are important in terms of zoonoses. These zoonotic diseases are mostly diagnosed at abattoir levels using conventional approaches; however, diagnosis and identification of these diseases using latest methods is an important aspect for ensuring meat safety and hygiene. Consequently, keeping in view this scenario, the current chapter has been developed to highlight the issue and spread the awareness about latest approaches by explaining its zoonotic aspects. Therefore, it is expected that such countries also take interest in proper cattle disease identification and diagnosis by adopting modern techniques in order to avoid zoonoses at abattoirs and to ensure the meat safety and hygiene.

3. Zoonoses occupationally acquired by abattoir workers

Zoonoses are illnesses and infections that spread spontaneously from animals to people. They account for over 70% of recently developing infectious illnesses [8]. More

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than 300 zoonotic diseases with various etiologies are known to have considerable morbidity and mortality [9]. Zoonotic infections can affect people of either sex, of any age, in any season, in any climatic zone, and both urban and rural settings [9, 10]. Together with the migration of animals across international borders to increase the local supply and the rising demand for meat and meat products, human interaction with animals has reached record levels, raising the danger of zoonotic diseases, particularly in endemic zones [11]. Numerous methods exist for zoonotic infection transmission [12, 13]. But among those who work in slaughterhouses, direct contact appears to be the

Microorganism	Disease	Reservoir	Host
Bacterial zoonoses			
Bacillus anthracis	Anthrax	Soil, animals	Cattle, pig, sheep, and horse
Erysipelothrix rhusiopathiae	Erysipelothricosis	Pig	Cattle, sheep, fish, horse, birds, and reindeer
Brucella abortus, B. suis and B. melitensis	Brucellosis	Animals	Cattle, horse, camel, sheep, goat, and poultry
Listeria monocytogenes	Listeriosis	Plant matter	Cattle, sheep, goat, horse, rabbit, and bird
Francisella tularensis	Tularemia	Tick, rodents	Deer, horse, and calf
Leptospira	Leptospirosis	Rodents	Cattle, camel, sheep, goat, and pig
Staphylococcus aureus	Staphylococcal infection	Cattle	Cattle, camel, sheep, goat, and pig
Clostridium tetani	Tetanus	Soil	Cattle, sheep, and pig
Fusobacterium necrophorum	Necrobacillosis	Soil, animals	Cattle, goat, and pig
Mycobacterium bovis	Tuberculosis	Cattle	Cattle, camel, sheep, goat, and pig
Chlamydophila psittaci	Chlamydiosis	Mammals and birds	Cattle, sheep, goat, and pig
Coxiella burnetii	Q-fever	Cattle, tick, sheep, goat	Cattle, sheep, and goats
Dermatophilus congolensis	Dermatophilosis	Cattle	Cattle, camel, sheep, goat, and pig
Viral zoonoses			
Louping ill virus	Louping ill	Sheep, tick, deer	Cattle, sheep, goat, and pig
Pseudocowpox virus	Pseudocowpox	Cattle	Cattle
Cowpox virus	Cowpox	Rodents	Cattle
FMD virus	Foot and mouth disease	Cattle	Cattle, camel, sheep, goat, and pig
Miscellaneous zoonoses			
Sarcoptes scabiei	Scabies	Animals	Cattle, camel, sheep, goat, and pig
Microsporum, Trichophyton	Dermatophytosis	Animals	Cattle, sheep, goat, and pig
Aspergillus fumigatus	Aspergillosis	Environment	Cattle, camel, sheep, goat, and pig

Table 1.
Diseases, causative agents (microorganism), reservoirsm and hosts of cattle-related abattoir zoonoses.

most typical way for pathogenic agents to enter [14]. Due to their intimate contact with animals and animal tissue during slaughter or processing, workers in the meat industry are particularly at risk of contracting several zoonotic illnesses [9, 10, 15]. The current study focuses on the zoonoses that abattoir employees who kill food animals mainly cattle. The diseases, causative agents (microorganism), reservoirs, and hosts of cattle-related abattoir zoonoses are summarized in **Table 1**.

3.1 Bacterial zoonoses

3.1.1 Erysipelothricosis

Erysipelothrix rhusiopathiae is the causative agent of this contagious bacterial illness. The condition is also known as Whale finger, Pork finger, and Fish finger [9]. Infections in humans are typically acquired from occupational exposure at slaughter-houses for meat, poultry, or fish. *E. rhusiopathiae* is widely distributed, with domestic pigs serving as its primary reservoir. Pigs, sheep, cattle, horses, fish, birds, and reindeer have all been shown to be infected [9]. The most susceptible occupations to disease are those handling and inspecting meat [14].

3.1.2 Brucellosis

This is one of the most significant anthropozoonoses in terms of public health, and it is brought on by *Brucella abortus, Brucella suis, and Brucella melitensis* [16]. Buffalo, cattle, camels, horses, pigs, sheep, goats, deer, and birds have all been recorded to have it [9]. Known as "undulant fever" or "Malta fever," human brucellosis is a severe zoonose that frequently affects livestock. All slaughterhouse employees who handle livestock directly, dress carcasses, or dispose of condemned organs run a higher risk of contracting brucellosis.

3.1.3 Listeriosis

Listeria monocytogenes, a rod-shaped bacterium that is the etiologic agent, was discovered by Murray in 1926 in rabbits and guinea pigs [9]. Buffalo, cattle, goats, sheep, houses, birds, rabbits, and fish are all susceptible to infection [9]. Direct contact with sick animals or contaminated discharges or tissues can cause veterinarians and butchers to develop primary cutaneous listeriosis [14]. The first sign of cutaneous listeriosis is a reddish rash, which progresses to vesicular or pustular lesions that are about 1–2 mm in diameter and have either a dark or light center [14]. It can occasionally result in a more widespread illness.

3.1.4 Anthrax

Bacillus anthracics, a Gram-positive, aerobic, sporulated bacterium, is the source of this occupational disease [17]. All food animals have been shown to have the illness. When conditions are right, the spores can survive in contaminated soil for 40–50 years and in dead host bones for 150–250 years. Between 20,000 and 100,000 cases of anthrax in humans are thought to occur annually on a global scale. 95–99% of all human cases worldwide are of the cutaneous type, also called malignant pustule [13]. It is widespread throughout the world, including Asia and Africa. Most often, an illness spreads to abattoir employees through a skin wound. The hands and arms of meat handlers appear to be more frequently affected by cutaneous anthrax [14]. The so-called "Malignant Pustule," a tiny pimple that quickly grows into a large blister with a dark necrotic centre, distinguishes it.

3.1.5 Leptospirosis

Weil's illness, mud fever, canicola fever, and rice-field worker's disease are just a few of the many names for this widespread bacterial zoonosis by pathogenic *Leptospira spirochetes* [18]. The illness, widespread in underdeveloped nations and reemerging in the United States [19], affects humans and animals. Numerous food animals, including cattle, buffalo, camels, horses, goats, sheep, deer, and pigs, are susceptible to leptospirosis [9]. Leptospira infection is thought to be resistant in poultry. Direct interaction with infected animals and their tissues can cause transmission, as indirect contact with a contaminated environment, particularly water tainted with the urine of infected food animals [20]. Brown and colleagues [21] investigated the environmental risk factors for leptospirosis in butchers in Jamaica.

3.1.6 Tularemia

Francisella tularensis, a Gram-negative, aerobic, non-sporulated bacterium, is the disease's cause and is often referred to as Deerfly fever or Rabbit fever [9]. Rabbit, deer, horse, pig, and calf cases of the disease have been documented [9]. It affects butchers of rabbits as a profession. The most prevalent way humans become infected is through skinning infected rabbits and hares. The USA annually reports roughly 2000 cases of human tularemia [14]. The first indication in men is typically a papule at the primary infection location, frequently an ulcerated finger.

3.1.7 Tetanus

It is a bacterial illness brought on by the spore-forming, Gram-positive, anaerobic bacterium *Clostridium tetani*. Horses, sheep, cattle, and pigs are all known to get natural infections [9]. The pathogen entered the body when contaminated soil or dust contaminated with *C. tetani* spores infected the incision, injury, or laceration. Incubation lasts 4–10 days. The first sign of tetanus is a tightening of the jaw muscles. The condition known as "Lock Jaw" affects men [9].

3.1.8 Melioidosis

Burkholderia pseudomallei, a Gram-negative, mobile aerobe, is the culprit [9]. Man contracts the virus through direct skin-to-contaminated-soil or water contact. The disease can also be transmitted by inhaling infected dust through the respiratory system. Cattles, camels, goats, horses, pigs, sheep, and kangaroos all contract diseases [9]. In dirt and water, organisms can endure for several months. Vesicles and pustules appear on the patient's hands and feet. There are septicemic, extrapulmonary, and pulmonary types. Australia has a high endemicity of disease in humans and animals [14].

3.1.9 Tuberculosis

Bovine tuberculosis, a severe zoonotic disease, is caused by *Mycobacterium bovis*. The occurrence of *M. Bovis* infection in animals and humans varies significantly globally. *M. Bovis* causes 5–10% of all cases of human tuberculosis in several underdeveloped nations [22]. Cattle, buffalo, sheep, goats, horses, pigs, and deer have all been recorded to have the disease [9]. Direct contact with an infected animal or carcass in an abattoir results in the spread of bacteria from an animal to a human (occupational exposure). The epidermis, tendons, and regional lymph nodes of people who touch infected carcasses in the slaughterhouse develop tuberculosis sores.

3.1.10 Necrobacillosis

A bacterial infection caused in humans, cattle, and goats. By touching infected animal tissues through a wound or damaged area of skin, a disease can be transmitted from an animal to a human. *Fusobacterium necrophorum*, an anaerobic, Gram-negative, non-sporulated bacteria, is the source of disease. At the location of the organism's injection, necrotic pustules form [9].

3.1.11 Dermatophilosis

Dermatophilus congolensis, a facultative anaerobic actinomycete, is the disease-causing agent. Due to how frequently it appears raindrops have just landed on the skin, the disease is occasionally called "rain scald." Initial symptoms of the illness include pustules, which are frequently disregarded. However, once the longer hairs become entangled in the scab, the pustules quickly clump together to create enormous oval crusts [11]. It affects cattle, goats, sheep, horses, camels, deer, and rabbits [23]. It has a widespread distribution.

3.1.12 Chlamydiosis

Chlamydophila psittaci, an intracellular organism, is the cause of this highly contagious disease that affects people all over the world. Animals, including cattle, sheep, horses, goats, pigs, buffalo, and birds, have been known to be infected [11]. Infection may develop from human exposure to infectious aerosols, dust, bird droppings, nasal discharge, and sheep fetuses and membranes [14, 24]. With good care, the illness seldom results in death. Early diagnosis and awareness are crucial as a result. A bird handler in India was found to have chlamydial infection.

3.1.13 Q fever

It is a severe rickettsial illness brought on by *Coxiella burnetii*. The organism has been contagious in farm dust and wool for a long time. Sheep, goats, and cattle are most frequently affected by the disease. Man can become inflected from inhalation, direct contact, or tick bites [9]. Fever, anorexia, chills, frontal headache, myalgia, weakness, cough, chest pain, pneumonia, and excessive sweating are the typical symptoms [9]. Pericarditis, endocarditis, and hepatitis are seen in more severe cases. In a study of employees at an Edinburgh slaughterhouse, 21.1% displayed antibodies to the phase 2 antigen of *C. burnetii* [14]. Infection among abattoir employees has been documented in Australian investigations during the past 20 years [25–27].

3.2 Viral zoonoses

3.2.1 Cowpox

Man can contract this viral zoonosis from infected cattle through close contact, which is how the cowpox virus (DNA virus) that causes it spreads. Acute viral illnesses like cowpox are distinguished by typical vesicular skin and mucous membrane outbreaks. Erythema, vesicles, pustules, and scab development are observed in men [9]. Some lesions on the hands, arms, and face are frequently accompanied by lymphadenitis and fever. The illness is self-contained. The hand of a butcher showed the characteristic cowpox lesions.

3.2.2 Contagious ecthyma

It is an occupational disease caused by Orfvirus (DNA) of family Poxviridae. There are cases of disease in cattle, sheep, goats, and camels. Abrasions or injuries to the skin can allow the virus to enter [3]. Man contracts the disease through direct contact with infected animals. The majority of instances are found in adults, particularly men. Butchers, meat handlers, and employees at abattoirs frequently contract diseases. Papule, vesicle, and pustule occur mainly on the finger, hand, wrist, fore arm, and sometimes on the face [14]. The lesions heal in 15–30 days, and occasionally, ocular lesions may occur [9].

3.2.3 Foot and mouth disease

It is an economically important infectious disease caused by FMD virus (RNA) of the family Picornaviridae and is reported in cattle, buffalo, camel, goat, sheep, pig, and deer [9]. Abraded skin that has been exposed to diseased animals or their excretions comes into close contact and spreads the infection. Viruses can persist for a very long time in animal hides. It is a mild disease in man and vesicles occur on the finger, palm of hand, sole of feet, or oral cavity [9].

3.2.4 Rift valley fever

Rift valley fever is caused by the rift valley fever virus (RNA), which belongs to the Bunyaviridae family and was first identified in Kenya in 1931. Man gets infection by direct contact with diseased animals or infected tissues [28]. A mosquito bite can infect both humans and animals with sickness. There are cases of disease in sheep, goats, camels, and cattle. A mosquito bite can infect both humans and animals with sickness. There are cases of disease in sheep, goats, camels, and cattle.

4. Diagnosis and identification of zoonotic diseases

Different goals are achieved by meat inspection (MI) operations carried out in slaughterhouses. MI activities were initially created with the primary goals of safeguarding consumers from foodborne dangers and assuring food safety and quality [29]. More recently, MI activities have expanded their scope to include, in particular, the supervision of animal health and welfare status [30]. Regulation (EU) 2017/625 of the European Parliament and the Council [31] and Commission Implementing Regulation (EU) 2019/627 [32] both contain regulations governing MI in Europe. The Competent Authority (CA) of each Member State conducts a series of actions at the slaughterhouse under the auspices of MI that are designed using a risk-based methodology. These actions take place before and after the animals are stunned or killed, and some of them include antemortem inspections (AMI) and postmortem inspections (PMI) [33]. At the European [34–37] and Italian levels, there are a number of recently published studies that mostly focused on lesions produced from PMI rather than AMI [38–40]. The information gathered at the abattoir during PMI is unquestionably crucial because it may be a sign of specific diseases or of subpar welfare [41]. However, the outcomes of AMI can help with a number of pig health and welfare issues as well as recommend what should be done when specific criteria are met at the abattoir.

In reality, although PMI in animals in European slaughterhouses is only visual [38], official veterinarians (OVs) can decide regarding additional procedures like physical examination and incision of organs in cases of a suspected risk for public health, animal health, or animal welfare during the AMI [42]. This is unless otherwise specified by procedures required for exporting meat and meat products in non-EU countries. Therefore, AMI operations may aid OVs in recognizing the batches of pigs that are unsuitable for visual inspection alone and that need more involved inspection techniques [43]. In reality, although PMI in animals in European slaughterhouses is only visual [38], official veterinarians (OVs) can decide regarding additional procedures like physical examination and incision of organs in cases of a suspected risk for public health, animal health, or animal welfare during the AMI [42]. This is unless otherwise specified by procedures required for exporting meat and meat products in non-EU countries. Therefore, AMI operations may aid OVs in recognizing the batches of pigs that are unsuitable for visual inspection alone and that need more involved inspection techniques [43].

In order to apply such measures, both OVs and food business operators (FBOs) need specific and reliable indicators that can facilitate the decision-making process. Little is known concerning the relationship between findings reported during AMI and those found during PMI in abattoirs [44]. To the best of our knowledge, a determination of the predictive value of certain conditions presents during AMI with respect to lesions assessable during PMI in slaughtered animals should be focused.

5. Emerging pathogen detection pathway

As people, animals, and viruses interact more intensely and intricately across local and global environments, there is a greater chance that a zoonotic pathogen with actual pandemic potential could emerge, endangering the life of millions of animals and humans. By necessity, the first signs of this threat must be observed locally, with sick people (or animals) being observed by someone acquainted with the local diseases. This initial discovery is typically never reported outside the surrounding area because the disease is not rare and spreads slowly. However, in some cases, the identification of initial cases or the subsequent chain of multiple events may result in the eventual involvement of the local or national state authorities as well as the potential intervention of international health responders. In many nations, centralized systems have been established, where epidemiologic and laboratory diagnostic capabilities are housed in national-level centers that serve as referrals and are located far from the majority of the high-risk human-animal interfaces that are the forerunners of disease emergence [45]. In these situations, clinical data on patients or animals, news of mass deaths or other uncommon illnesses, and finally diagnostic samples for examination are pulled up to these referral centers from the local level.

Despite its benefits, this centralized pull method has a number of failure points, since it might be challenging to get information and diagnostic samples from the home to the national level. Delays in the identification, diagnosis, and ultimately control of emerging health threats are caused by a variety of factors, including inadequate transportation or information systems, a lack of trained health workers, inadequate laboratory frameworks, poor multidisciplinary or ministerial communication channels between the animal and public healthcare organizations, mistrust of government officials, and occasionally less-than-ideal national reporting systems.

How to best build robust and durable surveillance networks that can identify the rare and isolated health event at the regional level and correlate those evaluations with highly qualified public health laboratory workers is the main challenge in the early screening of growing zoonoses at a systems level [46]. Is it more likely for a distributed network of local partner-driven surveillance teams with basic laboratory capacity for point-of-care rule-in/out diagnosis to be successful than a highly centralized and concentrated network in national- or regional-level reference institutions or government ministries, or even a combination of both? The sustainability of money, the requirement for training, and the sophistication of laboratory procedures required for pathogen detection are important factors that determine which of these approaches is most suited for a given nation. In various nations, examples of accomplishments from a combined effects of national and local monitoring networks with assistance from international organizations have been produced [47, 48].

The best-positioned disease surveillance systems to quickly identify emerging zoonotic hazards are probably those that strive to connect the animal and human health sectors as closely as is practical. The objective of these combined surveillance operations is to identify novel emerging diseases from susceptible animals and the human population as promptly as feasible. Field ecology teams and human and animal health professionals will collaborate on these activities. It may be best to combine this integrated strategy with initiatives to bring the technical expertise and laboratory facilities required for zoonotic disease detection as near to the local levels as possible. Systems that use a locally driven and distributed component may be more expensive and challenging to manage than exclusively centralized systems, but because they are closer to and more integrated into the local community, they are more likely to be able to quickly identify rare health events for follow-up.

6. Building an effective approach

The development of local or regional surveillance centers is necessary for integrated approaches to be viable. This requires long-term, sustainable financing and investments in human capital, infrastructure, laboratory equipment, and these areas. In response to the SARS outbreak in 2001, 196 World Health Organization (WHO) member countries adopted International Health Regulations (IHR) in 2005, which has accelerated the establishment of integrated animal and human health surveillance systems for zoonoses [49]. The opportunity to more closely link the human and animal disease surveillance sectors has been made possible by these restrictions, together with the growing understanding that the appearance of a disease in one nation might quickly spread to another through the movement of animals or humans. IHR requires the timely notification (<24 h) of outbreaks "of disease with the ability to cause serious public health impact and to spread internationally" and may constitute a "Public Health Emergency of International Concern" [50]. The regulations do not stipulate the source of the infection (human or animal) and are meant to be applied as broadly as possible by all member nations.

Finding local, national, and regional partners to work with these multinational organizations, create structures with them, and find bright and motivated people is a crucial initial step in this process. To create a knowledgeable and well-coordinated network of people and institutions for zoonotic disease detection, these individuals should ideally come from a variety of scientific backgrounds and work in all fields, including human, animal, and wildlife health specialists, epidemiologists, laboratory and behavioral scientists, and other junior and senior staff.

7. Conclusion

A lack of latest approaches in diagnosis and identification of zoonotic diseases at abattoirs can endanger the lives of livestock owners, butchers, and public. There is an even greater risk of meat-borne zoonoses in this facility, given that most home slaughter slabs and abattoirs are not fully controlled and that there is a higher level of interaction with raw meat. In most of the countries, diagnosis and identification of these zoonotic diseases at abattoirs is performed by conventional ways such as by antemortem and postmortem examinations. However, latest approaches should be adopted to avoid such bacterial and viral zoonoses.

Conflict of interest

The authors declare no conflict of interest.

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