

PORCINE RESPIRATORY DISEASE COMPLEX (PRDC):
A REVIEW. I. ETIOLOGY, EPIDEMIOLOGY, CLINICAL
FORMS AND PATHOANATOMICAL FEATURES

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Summary

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The porcine respiratory disease complex (PRDC) is a relatively new disease with rapidly increasing importance for the industrial intensive pig breeding. The main causative agent is *Mycoplasma hyopneumoniae* and secondary pathogens – the porcine reproductive and respiratory syndrome virus (PRRSV), swine influenza virus (SIV) and *Actinobacillus pleuropneumoniae*. The disease is primarily seen in large pig farms with continuous production systems where the opportunity for exchange of microflora is more favourable. Mainly young animals from the growing and fattening groups are affected. The leading factor in the pathogenesis is the interaction between *M. hyopneumoniae* and PRRSV. The clinical manifestations depend on the production system and the pathogens involved in the complex. The pathoanatomical changes are various and non-specific, being a combination of the impact of the various agents.

Key words: lungs, mycoplasmae, pigs, porcine reproductive and respiratory syndrome virus (PRRSV), porcine respiratory disease complex (PRDC)

INTRODUCTION

During the last 10–15 years, the so-called porcine respiratory disease complex (PRDC) is becoming more and more prevalent initially in the USA and later, in Europe. It comprises several diseases that could also occur independently, but frequently, a mixed infection etiologically related to at least three infectious agents is observed. Most commonly, *M. hyopneumoniae*, viruses (particularly the porcine reproductive and respiratory syndrome virus: PRRSV), as well as bacteria – *Pasteurella multocida* and/or *Actinobacillus pleuropneumoniae* (APP) are evidenced in PRDC incidences (Dee, 1997;

Honnold, 1999; Thacker & Thanawongnuwech, 2002).

The emergence and development of this disease complex is primarily related to the penetration of PRRSV in swine populations and to the occurrence of the postweaning multisystemic wasting syndrome (PMWS) caused by the porcine circovirus type 2 (PCV-2). Several predisposing factors are thought to be important for its relatively fast distribution: introduction of more intensive production systems, selection of rapidly growing hybrids, creation of large pig breeding farms etc.

In Bulgaria, the informal statistics and indirect data are also indicative about a considerable spread of respiratory infections, especially in large farms. Motovski *et al.* (2003) observed a wide distribution of respiratory viruses and bacterial pathogens in swine reared in Bulgaria. The most prevalent were the Aujeszky's disease virus (pseudorabies virus, PRV) and APP (Motovski, 2003). In a serological investigation on the incidence of PRRSV, SIV, PRV and porcine retrovirus in swine dams in 1999, seroprevalences of 8.2% to SIV H1N1 and 90.7% to SIV H3N2 were detected. There was no seropositivity to PRRSV (Motovski & Paul, 1999).

In a similar study performed in 2001 among growing and fattening pigs, no antibodies against H1N1 were found out, the seroprevalence to H3N2 was 96.7 %, and no antibodies against PRRSV were observed (Motovski *et al.*, 2001). Yordanov (2000), having studied the incidence of APP in Bulgaria, has isolated 81 strains from 7 serotypes and 20 non-typed strains. Most commonly, serotype 5 was isolated. The same author suggested a plan for eradication of the infectious pleuropneumoniae (Yordanov, 2001).

An excellent review on PRDC was published by Motovski (2003). The rapid increase in data reported with this connection encouraged us to perform a new attempt for recapitulation of actual knowledge in this field.

ETIOLOGY

The microbial species involved in PRDC etiology are multiple and vary in the different farms with various rearing systems. *Mycoplasma hyopneumoniae* is usually referred to as the commonest agent. The enzootic pneumonia in swine is most commonly connected with this orga-

nism (Ross, 1999; Burch, 2004). At the next place, but not in order of importance, comes the PRRSV. Then follow the swine influenza virus (SIV), PCV-2, the porcine respiratory coronavirus (PRCV), and PRV.

APP and *Bordetella bronchiseptica* are accepted as primary agents, whereas *P. multocida* (in up to 43 % of slaughter findings – Falk *et al.*, 1991), *Streptococcus suis*, *Haemophilus parasuis*, *Actinobacillus suis*, *Salmonella Choleraesuis* (Brockmeier *et al.*, 2001; Honnold, 2001) are considered as secondary agents. The *Pasteurella* strains, isolated in pneumonias, are usually non-toxicogenic (Thacker, 2001).

From mycoplasmae, the *M. hyopneumoniae* species is especially important for PRDC. This microorganism is very fastidious. It is thought that the infection related to it is a triggering mechanism for the subsequent development of the respiratory disease complex (Thacker *et al.*, 1999a). As all other mycoplasmae, *M. hyopneumoniae* has no cellular wall and instead, its role is played by the cytoplasmic membrane. Because of their fastidious nature, mycoplasmae are cultivated on special nutrient media supplemented with porcine serum or in Friis's medium. Their isolation from organ material is difficult and therefore, the diagnostics used mainly indirect methods of detection, mostly serological ones (Baumeister *et al.*, 1998; Calsamiglia *et al.*, 1999).

APP causes independently pleuropneumonia in pigs – an acute disease with a high mortality rates. This is a Gram-negative coccobacillus, fastidious with regard to nutrient media. The species is divided into 2 biovars (1 and 2), the first one having 12 serovars described until now and the other one – 3 (Taylor, 1999; Blackall *et al.*, 2002).

The PRRSV is a RNA virus belonging to the *Arteriviridae* family. It has an outer envelope and a diameter of 50–65 nm. PRRSV is relatively unstable out of host's organism (Benfield *et al.*, 1999). Two principal strains exist – an European one (Lelystad Virus, LV) and an American one (VR-2332) with numerous subspecies with a various virulence. Generally, they are divided into high- and low-virulent strains according to pulmonary alterations they are causing (Halbur *et al.*, 1995; Halbur *et al.*, 1996a). A characteristic feature of the virus is its significant mutability, responsible for the lack of a distinct limit among strains and subspecies (Holland, 1995).

SIV is also a RNA virus from the Orthomyxoviridae family, *Influenza A* genus. By now, three SIV types are circulating in Europe and the USA – H1N1, H3N2 “Hong Kong” and H1N2 (Castrucci *et al.*, 1993; Done & Brown, 1999; Van Reeth *et al.*, 2003). In Europe, H1N1 has passed from birds to swine in 1979 whereas in the USA, the classic, less virulent swine type H1N1 is encountered (Pensaert, 1981; Easterday & Van Reeth, 1999). H3N2 “Hong Kong” is transferred from men after the pandemic in 1968. In 1984 it is reassorted with the avian H1N1 virus. H1N2 was isolated in 1994 in Great Britain and later, in Belgium. It originates from a reassortment between a “Russian” human H1N1 virus and the already reassorted H3N2 (Brown *et al.*, 1998).

The porcine circovirus type 2 (PCV-2) belongs to the Circoviridae family and is very tiny (about 17 nm). Independently, it causes congenital tremor in newborn piglets, the postweaning multisystemic wasting syndrome (PMWS) (Clark, 1997), as well as the porcine dermatitis-nephropathy syndrome – PDNS (Smith *et al.*, 1993). A number of authors believe that

PRRSV was very commonly involved in PMWS etiology too – from 20 % of cases in Canada (Allan & Ellis, 2000) to 60 % in the USA (Sorden *et al.*, 1998), as well as *M. hyopneumoniae* – in about 36 % of cases (Halbur & Opriessnig, 2004).

EPIDEMIOLOGY

Prevalence

There are no precise data about the prevalence of PRDC on a global scale, because the manifestations of the disease complex are very variable depending on the conditions in the farm. In the USA, where the disease was described for the first time, more accurate data are available (Halbur *et al.*, 1993). In 1993–2000, the incidence of pneumonia recorded in the diagnostic laboratory of the University of Iowa, caused by PRRS, *M. hyopneumoniae*, SIV, *P. multocida* and *S. suis* has increased 13, 4, 6, 3 and 3 times, respectively. The prevalence of pneumonia, caused by PCV-2, has increased 456 times for the same period, whereas for APP, no augmentation was detected (Halbur, 2001). The data provided by the Veterinary Diagnostic Laboratory of the University of Minnesota, evidenced that in 88.2% of the 2872 pulmonary pneumonia specimens collected in 2000–2001, 2 or more microorganisms were isolated, the commonest combination being PRRSV + *P. multocida* (10.4 %), followed by PRRSV and *M. hyopneumoniae* (7 %) and PRRSV + APP (6.2 %) (Choi *et al.*, 2003).

The results from an ELISA serological survey on 13 farms in Bulgaria performed in the Department of Veterinary Microbiology, Infectious and Parasitic Diseases, Faculty of Veterinary Medicine at the Trakia University – Stara Zagora between

April 2003 and October 2005, showed seropositivity towards *M. hyopneumoniae* in all (100%) farms, the individual seroprevalence varying from 4.5 to 100 % (Table 1).

The enzootic pneumonia in pure and more frequently, mixed form, is one of the commonest infectious respiratory diseases in pigs (White, 2003). Up to 80 % of all pigs and 90 % of swine herds all over the world are affected (Clark, 1999; Fano *et al.*, 2005). In Great Britain, more than

90 % of herds are infected and pulmonary alterations throughout slaughter inspections was reported to vary between 40% and 50 % (Burch, 2004). In a study comprising 12 farms with respiratory problems in Spain, 100% prevalence among farms was determined, and in the individual farms, 3% to 44% of studied animals were found to be positive (Sibila *et al.*, 2004). In a serological survey of 50 farms in Belgium, 88% of them were seropositive (Maes *et al.*, 1999). In Cana-

Table 1. Seroprevalence of *M. hyopneumoniae* in 13 pig farms from different regions of the Republic of Bulgaria *

Farm	Number of studied animals			
	Total	Positive (%)	Negative (%)	Suspicious (%)
“Ameta Holding” – Han Asparouhovo	44	33 (75)	7 (15.9)	4 (9.1)
“Mihaela V. Zhelyazkova” – Han Asparouhovo	44	2 (4.5)	41 (93.2)	1 (2.3)
“TEDDI” – Oryahovitza	44	10 (43.2) sero-prevalence 53.8%	9 (20.4)	16 (36.4)
“Ayax 95” Ltd	44	5 (11.4), 40% of fattening pigs	33 (79.5)	6 (9.1), 20% of fattening pigs
“Biocom Ltd” – Sliven	22	9 (40.9)	10 (45.45)	3 (13.63)
“Reproduktorno svinevadstvo” – Yambol	44	9 (20.45)	30 (68.18)	5 (11.36)
Hybrid Centre of Pig Breeding – Shoumen	46	4 (8.7)	39 (84.8)	3 (6.5)
Pig Farm – Brashlen	46	26 (56.5), 14 (66.6) of growing pigs	11 (23.9), 3 (14.28) of growing pigs	9 (19.6), 4 (19) of growing pigs
“Belsuin Ltd” – Septemvriitsi	44	29 (65.9)	11 (25)	4 (9.1)
“Geostroy Engineering Ltd” – Yambol	44	44 (100)	0	0
“Biovet” – Peshtera	30	30 (100)	0	0
Udelnik	4	3	0	1
Sitovo	28	18 (64.3)	8 (28.6)	2 (7.1)
Total	484	231 (47.7)	199 (41.1)	54 (11.2)

* results from a survey performed in the Department of Veterinary Microbiology, Infectious and Parasitic Diseases, Faculty of Veterinary Medicine, Trakia University, Stara Zagora, through ELISA, for the period April 2003 – October 2005 (Lyutchanov, M. & A. Vachkov, personal communication).

da, pneumonic changes have been observed throughout slaughter inspections in 81.6% of pigs in the summer and 76.3 % in the winter (Wilson *et al.*, 1986).

With respect to PRRS, between 50% and 80% of farms in the USA were reported to be affected (Halbur, 1997). As PRRS is endemic in most countries, there are PRRSV-free herds in all countries. The percentage of seropositive farms could be hardly determined because the antibodies formed following vaccination with live vaccine could not be distinguished from those caused by a wild virus and also because of the infection of non-vaccinated animals with a vaccinal strain (Morgan Morrow & Roberts, 2001). In Europe, the prevalence of the virus varies in a wide range – from 1–7% of serologically studied animals in Slovenia (Valenchak, 2004) to 43% in France (Pommier *et al.*, 2003).

The data about the prevalence of SIV in Europe show a frequency between 92% for H1N1 and 57% for H3N2 in Belgium to 54% and 13%, respectively in Holland (Heinen, 2003). In the USA, SIV was detected in 32% of studied animals: H1N1 – in 67 %, H1N2 – in 5 % and H3N2 – in 27% of cases (Choi *et al.*, 2002).

APP is also widely spread all over the world. Apart in all Europe, enzooties are reported in USA, Canada, Mexico, South America, Japan, Korea, Taiwan, Australia. Various serovars are prevalent in the different countries (Taylor, 1999).

Sensitivity

The disease complex affects predominantly the growing and fattening pigs (Dewey, 2000).

The pigs of all ages are susceptible to mycoplasmosis, but most commonly, growing pigs at the age of 12 to 14 weeks are affected (Halbur, 1997). Depending on the production technology and the health

status of the farm, the age of appearance of the first pathological changes could shift back to an age of 6 weeks (Ross, 1999) or forward to 18–20 weeks (Joisel *et al.*, 2001). All ages are sensitive to APP (Crujisen *et al.*, 1995). The newly weaned pigs are most sensitive to the PRRSV because maternal antibodies are depleted by the 2nd to the 5th week after the birth. Pigs at the end of the fattening period are generally the most sensitive to SIV, but recently the disease is observed in a more protracted form in newly weaned piglets (Halbur, 1997). There are no data for breed- or gender-related susceptibility to the main causative agents of PRDC.

Sources of the infection

The main source of infection are clinically ill pigs and pigs, carriers of infection. The carriership gradually increases with age and in mycoplasmatic infection, it is the highest in young swine dams and then the prevalence decreases (Batista *et al.*, 2002, Bush, 2002). Affected animals excrete the agents primarily with the expired air throughout coughing and also, by the other routes. The dams shed a small amount of mycoplasmae after their third litter, have a stable immunity and usually do not pass the infection to their offspring (Joisel *et al.*, 2001). In PRRSV, a persisting infection with carriership of the virus for up to one year in tonsils is often observed. Shedding of the virus is detected up to 157th day of the infection (Wills *et al.*, 1997a), and carriership – for up to 251 days (Wills *et al.*, 2003). Because of the immunosuppressive effect of the virus in pigs infected intrauterinely during the last trimester of the pregnancy, a prolonged viraemia in the presence of antibodies is observed (long term viraemic pigs, LTVP) (Halbur, 1997). Once penetrated the farm, the PRRSV is hardly eradicated because

of viral persistence, accompanied with emergence of subpopulations with various immunity, among which the virus is circulating (Dee *et al.*, 1993). In SIV, shedding for more than 30 days is not proved (Easterday & Van Reeth, 1999). Pasteurellosis and streptococcal infection occur very often endogenously because of the asymptomatic carriership in the upper respiratory tract.

Transmission of the infection

In mycoplasmosis and PRRS, the infection occurs mainly aerogenically throughout a direct contact (Goodwin & Whittlestone, 1967; Farrington, 1976; Benfield *et al.*, 1999). The airborne transmission of PRRS takes place only within several metres (Toremorrell *et al.*, 1997), but in case of mycoplasmosis, the airborne infection could be realized at a distance up to 3.2 km between farms (Goodwin, 1985).

In PRRS there are also other mechanisms of infection transmission – vertical (transplacental) (McCaw, 1995) and horizontal – orally via food and water, infected with saliva, urine and milk, containing the virus (Wills *et al.*, 1997a), via contaminated objects and equipment (Dee *et al.*, 2003), as well as venereally by infected semen (Swenson *et al.*, 1994). The transmission by blood sucking insects is also possible (Otake *et al.*, 2002) and probably, by biting (Benfield *et al.*, 1999). The shedding of the virus in faeces is dubious (Yoon *et al.*, 1993; Wills *et al.*, 1997b). Mallard ducks could become infected with the virus and to spread it after experimental infection for up to 39 days (Zimmerman *et al.*, 1997).

The spread of SIV is also airborne. Transmission among farms could be easily performed by waterfowl, that are the main reservoir of influenza viruses in nature.

Predisposing factors

Overcrowding is an important predisposing factor (Gemus, 1996). From all climatic factors, the greatest impact is that of big diurnal temperature variations, air currents, air pollution with dust (usually by dusty feed), the increased ammonia concentration (>50 ppm) etc. (Robertson, 1993). The insufficient amount of drinking water and the inadequate feed could also influence the onset as well as the severity of infections from the respiratory diseased complex. Apart the factors that are generally predisposing to respiratory infections, there are more specific causes, the most important of which are as follows:

1. Big herds with great variations of age in the same premise.
2. Frequent moving and sorting of pigs.
3. Introduction of infected replacement animals.
4. Changing meteorological conditions causing stress especially in open non-mechanical ventilation systems (weaker ventilation in winter months) (Gemus, 1996).
5. Phase (unified) feeding – a regimen, not suitable for all pig categories (Halbur, 1997; Thacker, 2002).

The respiratory disease complex is manifested most commonly as enzooty (Halbur, 1997; Dee, 1997), the morbidity rate of PRDC in different farms in the USA being between 30% and 70%, and mortality rate – about 4–6% (Halbur, 1997; Thacker, 2002), but could reach up to 15% in some farms (Choi *et al.*, 2003).

For PRRS in Canada, the seasonal occurrence is mainly in winter, whereas for mycoplasmatic infection and influenza, there is not a marked seasonal pattern (Choi *et al.*, 2003; Bomgaars, 2003).

PATHOGENESIS

The potentiating effect of mycoplasmae in relation to other pathogenic bacteria, has been established primarily for *P. multocida* (Ciprian *et al.*, 1988). However, the synergism between *M. hyopneumoniae* and PRRSV has a leading role. Mycoplasmae are extracellular parasites whose pathogenic effect is exerted by attachment to the villi of respiratory epithelium and provoking of ciliostasis. The PRRSV affects mainly the alveolar macrophages and provokes an acute interstitial pneumonia (Rossow *et al.*, 1995; Halbur *et al.*, 1996b; Thanawongnuwech *et al.*, 1997). Both microorganisms escape the immune defense of the host. For PRRSV, this is due not only to the destruction of macrophages, but to its repeated mutability (Meng, 2000; Thacker & Thanawongnuwech, 2002). In case of mycoplasmae, the weak immune defense is due to their colonization of the respiratory epithelium where there could hardly be reached by antibodies and the cells of defense (Thacker *et al.*, 1999a). In mixed infections, pathogens are mutually aiding each other, but when the initial infection is caused by *M. hyopneumoniae*, it attracts lymphocytes and macrophages, stimulating their division. Thus, peribronchial and perivascular infiltrates of monocytes are formed, that are actively dividing and are appropriate hosts for the PRRSV (Thacker *et al.*, 1999a). When the initial infection is with the PRRSV, no macroscopic changes are observed, but on a microscopic level, the damages are more than those after a monoinfection (Thacker *et al.*, 1999a). Despite the injury of macrophages, a general immunosuppression in PRRSV infection, that could result in the development of secondary bacterial infections has not been definitely evidenced (Drew, 2000). Although an increased

mortality was observed in suckling and newly weaned piglets in bacterial infections accompanying PRRS, (Beilage, 1995; Done & Paton, 1995), only once an enhanced susceptibility to bacterial infections was experimentally proved (Galina *et al.*, 1994).

In *M. hyopneumoniae* and SIV co-infection, only an additive type of interaction was noticed. Both agents damage the ciliary epithelium and open the entrance door for other bacteria. (Thacker *et al.*, 2001).

PCV-2 was most commonly associated with PRRSV (Wellenberg *et al.*, 2003; Halbur & Opriessnig, 2004), and a synergic interaction between them was established (Harms *et al.*, 2001; Rovira *et al.*, 2002). PCV-2, similarly to PRRSV, is reproduced in histiocytes and macrophages. It provokes a reduction in lymphocyte counts in lymph nodes and tonsils that is probably accompanied with immunosuppression (Krakowka *et al.* 2002). The commonest clinical form of PCV-2 infection is PMWS. This syndrome is somewhat similar to PRDC, but affects younger animals (8–16 weeks old) and is accompanied by neither fever nor cough (Harding & Clark, 1997; Allan & Ellis, 2002; Kim *et al.*, 2002). In Denmark, Vigre *et al.* (2006) established a much more frequent association of the PCV-2 with the American type PRRSV, than with the European one.

It was experimentally shown that in a co-infection, *M. hyopneumoniae* stimulates the reproduction of PCV-2 in peribronchial lymphoid proliferates, and the pneumonic alterations were more severe than in cases of single infections (Opriessnig *et al.*, 2004). In tracheobronchial lymph nodes, the production of IFN γ and other cytokines was considerably higher than in monoinfections with the

respective pathogens (Opriessnig *et al.*, 2006). In a PRRSV and SIV co-infection, the clinical manifestations are also more severe (Van Reeth *et al.*, 1994; Thacker *et al.*, 1999b). PRRSV enhances also the pathogenic impact of *S. suis* (Halbur *et al.*, 2000).

Among the different agents, antagonism could be observed as well. Motovski *et al.* (2003) reported antagonism between the SIV and the PRV.

The pathogens, influencing directly the respiratory immune system (*M. hyopneumoniae*, PCV-2 and PRRSV) predispose the host to supplementary infection with less pathogenic microorganisms (Thacker, 2003).

CLINICAL SIGNS

Due to the polyetiological character of the disease complex, the clinical manifestations are various. There is no definite incubation period. According to Joisel *et al.* (2001), the outbreak is strongly influenced by the general immune status of the herd, the extent and degree of infection carriership as well as by the rearing technology. It is acknowledged that an active infection begins when at least 50 % of the animals in a herd are infected with *M. hyopneumoniae* (Joisel *et al.*, 2001). Under this threshold, the pig do not manifest an apparent infection. Several “development models” could be observed: In the mixed rearing system, the infection of 50% of pigs happens by the 4th week, whereas the seroconversion – by the 10th week of life. In the “all-in all-out” system (AIAO) with rearing in different premises in the same farm, 50% of stock pigs become infected by the 10th week and the seroconversion occurs by the 16th–18th week. This model is the commonest, observed in Europe (Joisel *et al.*, 2001). In

the three site system, where newborns, weaned and growing along with fattening pigs are separated, the development of the disease is the slowest. In such a case, the 50% threshold is reached by the 14th–16th week, and the seroconversion – prior to slaughtering. This most protracted model is observed the most frequently in the USA. It is assumed that the cause for this protracted manifestation of the disease is that the herd consists of subpopulations of pigs with a different immune status with regard to PRRSV, formed during the assembling fattening pig herds or because of an unstable parental herd (Dee *et al.*, 1996; Dee *et al.*, 1997; Honnold, 1999). This results in the development of an enzootic process and thus, the seropositivity to PRRSV in the typical fattening herd is gradually reaching almost 100% by the end of the fattening period but at the same time, the seroprevalence to *M. hyopneumoniae* exceeds the 50% threshold and the disease breaks out clinically (Halbur, 1997).

The most obvious clinical sing is the cough whose intensity is very important with regard to diagnostics. It is evaluated by a score system as follows: score 0 – total lack of cough in fattening pigs during moving; score 1 – less than 10% of pigs exhibit sporadic cough; score 2 – cough is present in 10%–15% of fattening pigs and it persists during moving; score 3 – persisting cough in more than 50% of pigs (Yeske, 2003).

The rate of infection and the immunity of dams, especially of primiparous ones, is very important for the development of disease. Usually, the disease starts suddenly in an acute form in the so-called (18-week wall) – in pigs at the age of 16–20 weeks (Dee, 1997; Halbur, 1997). The clinical signs are strong depression, fever, lack of appetite, accelerated respiratory rate

(not present in a PRRSV monoinfection – Halbur, 2001), expiratory efforts, fast emaciation (Schwartz, 2001; Deen, 1997). The dry sporadic cough is a sign for the involvement of mycoplasmae (Ross, 1999), and the wet, paroxysmal barking cough – for an influenza virus (Halbur, 1997). When APP is involved, the general condition is extremely worsened (Taylor, 1999).

GROSS ANATOMICAL CHANGES

The characteristic alterations observed during necropsy, are in lungs. They are quite variable and depend on the agents involved in PRDC, being a combination of the changes specific for the individual microorganisms. Because of the leading role of mycoplasmatic infection, the changes caused by the other agents are laid on mycoplasmae-induced injuries (Schwartz, 2002). The slaughterhouse findings are usually indicative for the stage of infection, rather than about its severity (Pijoan, 2002). The pure mycoplasmatic infection is characterized with thickening of cranio-ventral pulmonary lobes, generally the apical and cardiac lobes, that acquire a dense structure with a purple red to red brown or grey colour and a meat-like consistency. Such areas are atelectatic (Ross, 1999). Similar changes could be observed in SIV monoinfection (Schwartz, 2002; Thacker, 2002).

Because of the acute course of PRDC, the classical mycoplasmatic changes are replaced with more diffuse ones with a various character (Schwartz, 2002; Thacker, 2002). In a PRRS infection, the lungs' surface is initially mottled with light- and dark brown areas and the interstitium is thickened, that produces a thick consistency of pulmonary tissue (interstitial pneumonia). The lymph nodes are enlarged, especially the cervical, mediastinal and

inguinal ones. Microscopically, the early changes are typical for PRRSV infection: infiltration of alveolar septae with monocytes, hyperplasia of pneumocytes type 2 and accumulation of necrotic exudate in alveoli. Later, in a mixed infection, the characteristic mycoplasmatic alterations do appear – peribronchial and lymphohistiocytic proliferations (Thacker *et al.*, 1999a). In an experimental *M. hyopneumoniae* and PCV-2 co-infection (Opriessnig *et al.*, 2004) the picture was similar to this observed in *M. hyopneumoniae* + PRRSV infection – the lungs were not post mortally contracted and were mottled with brownish spots (signs typical for PMWS), the lesions being more extensive than those in a *M. hyopneumoniae* monoinfection. The lymph nodes were 2–3 times larger. Microscopically, an interstitial pneumonia with infiltration of alveolar septae with macrophages and lymphocytes, peribronchial and perivascular cuffs of lymphohistiocytes were observed. In a *M. hyopneumoniae* and SIV co-infection, there were larger pneumonic areas than during monoinfections by the 14th day, but by the 21st day of the infection they were similar in size with those of the pure mycoplasmatic infection. Microscopically, peribronchial and perivascular lymphoid infiltrations and desquamation of respiratory epithelium were noticed (Thacker *et al.*, 2001).

When *P. multocida* was involved, the apical and anterior parts of the diaphragmatic pulmonary lobes were diffuse dark red to grey, and the other parts – rose red or almost normal in appearance. There was a good demarcation between the intact and affected part. In the respiratory tract, exudate was found. Sometimes, pleuritis was observed (Schwartz, 2002). Apart the typical mycoplasmatic infiltrations, the microscopic alterations consist

also in lobular exudative bronchopneumonia. The involvement of *S. suis* usually results in pulmonary abscesses. The pattern of alterations changes vary dynamically depending on the stage of development of infection, reached at the time of slaughtering (Anonymous, 2005).

The pulmonary changes in cases where APP was the infective agent, were the most severe and the most extensive (Schwartz, 2002; Thacker, 2002). On its own, APP causes fibrinous haemorrhagic and necrotizing pneumonia, affecting the entire pulmonary wings (usually both of them), and characterized with substantial fibrinous depositions on the visceral pleura, resulting in its adhesion with the parietal one (Sebunya & Saunders, 1983; Taylor, 1999).

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