



Research Article

Assessing the Pathological Diagnostic Skills of Veterinary Students for Ovine Pulmonary Adenocarcinoma

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Abstract | Ovine pulmonary adenocarcinoma (OPA) is a contagious neoplastic disease of sheep caused by Jaagsiekte sheep retrovirus (JSRV). This study assessed the morphological and histopathological characteristics of OPA in sheep and levels of awareness and understanding of OPA in veterinary students. A survey among clinical-grade students revealed higher recognition of JSRV as the primary cause. Postmortem examination of affected sheep showed enlarged lungs with gray nodules and frothy fluid exuding from lung nodules. Histopathological analysis showed the proliferation of neoplastic cells in the alveolar and bronchial linings, displaying papillary, solid, or acinar patterns. These neoplastic cells replaced normal epithelial cells, while the surrounding stroma exhibited infiltration by mononuclear inflammatory cells. Additionally, secondary changes were observed in the kidneys, liver, and lymph nodes, including mild interstitial fibrosis, vacuolar degeneration, and lymphoid depletion, respectively. The study emphasizes the critical need for early diagnosis and the development of effective diagnostic methods to identify infected sheep and curb the spread of JSRV infection. These findings enhance students' practical skills in managing real-life cases and reinforce the value of histopathological examination in veterinary diagnostics.

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Introduction

Ovine pulmonary adenocarcinoma (OPA), also known as ovine pulmonary adenomatosis or ovine pulmonary carcinoma (OPC) or Jaagsiekte, is an infectious and contagious neoplastic disease of

sheep and, rarely of goats (Palmarini and Fan, 2001). It is a progressive respiratory disease, principally affecting adult animals (Caswell and Williams, 2016).

The disease is caused by an exogenous β -retrovirus, known as Jaagsiekte sheep retrovirus (JSRV), which

leads to the neoplastic transformation of the secretory epithelial cells in the lungs and bronchi (Palmarini *et al.*, 1999). While respiratory secretions are the major source of JRSV spreads, lambs may be infected vertically by consuming infected colostrum (Borobia *et al.*, 2016).

Clinical disease primarily occurs in sheep older than 2 years, with the highest incidence seen in those aged 3 to 4 years. In rare instances, the disease can affect animals as young as 2 to 3 months. Symptoms of respiratory distress, such as progressive dyspnea, tachypnea, nasal discharge, coughing, and weight loss, reflect the severity of lung tumor progression. Frothy milky fluid accumulates within the respiratory tract and may be observed pouring out of the nostrils after elevating the sheep's back and lowering its head the wheelbarrow test (Sharp and DeMartini, 2003).

There have been two forms of OPA; classical and atypical. In the classical type, sheep exhibit the aforementioned clinical symptoms and often have multifocal to coalescing neoplastic lesions in the cranioventral pulmonary lung lobes. The lungs are grossly heavy, moist, and do not collapse properly. Tumors on cut surfaces frequently have a grey, grainy look, and considerable volumes of fluid flow from them. In contrast, the atypical variety frequently progresses subclinically, with neoplasms visible in the diaphragmatic lung lobes. Atypical tumors are dry, whitish, and multifocal in distribution (Griffiths *et al.*, 2010).

In OPA, the pulmonary parenchyma contains multifocal or locally widespread neoplasms, with metastases to regional lymph nodes occurring in 0.3–25% of cases. More distant metastases are rare, but when they occur, they can spread to the following organs in order of frequency: Liver, kidneys, skeletal muscle, digestive tract, spleen, skin, and adrenal glands (Minguijón *et al.*, 2013).

The diagnosis of Jaagsiekte is based on clinical signs and postmortem investigation, because there are no existing cost-effective serological techniques for identification of JSRV infection, because the virus fails to elicit a specific antibody response in infected animals, and the disease can take time to progress from a subclinical to a clinical state within a flock, as it induces a condition of immunotolerance by integrating its DNA into the host's genome.

Consequently, serological tests conducted during the subclinical phase may yield false-negative results, potentially leading to severe disease, increased livestock mortality, and significant economic losses (Spencer *et al.*, 2003).

The diagnosis of OPA is challenging due to the delayed onset of clinical signs, which complicates early detection and timely implementation of control measures on affected farms. Moreover, the absence of reliable, routinely available diagnostic tools, such as serological assays or other non-invasive methods, leaves veterinary clinicians unable to accurately identify infected animals. This diagnostic gap also makes it nearly impossible to determine the true prevalence of OPA at the flock level. Consequently, histopathological examination remains the only definitive method for diagnosing OPA, offering conclusive evidence of the disease (Quintas *et al.*, 2021; Chen *et al.*, 2024). This study aimed to evaluate the morphological and histopathological characteristics of OPA in sheep while also assessing the awareness and understanding of the disease among veterinary students.

Materials and Methods

Animals

An accidental death of an adult sheep, aged 1.5–2 years, was recorded on a farm near the Faculty of Veterinary Medicine, Benha University. The sheep had a clinical history of emaciation and chronic respiratory distress that had been unresponsive to antibiotic treatment. This case was subsequently investigated to assess the pathological findings associated with the respiratory condition.

Survey of veterinary students

A survey was conducted among 94 veterinary students (49 preclinical and 45 clinical-grade students), who belong to Faculty of Veterinary Medicine, Benha University, Egypt, to assess their awareness and understanding of Ovine Pulmonary Adenocarcinoma (OPA). The survey included questions on participant demographics, knowledge of OPA, attitudes toward its diagnosis and management, and practical experiences with the disease.

Gross pathological examination

A comprehensive postmortem examination was performed on the dead sheep. Gross lesions were

documented, with particular attention given to the respiratory system.

Histopathological study

Small tissue specimens were collected from the lungs of dead sheep and immediately fixed in 10% neutral buffered formalin for 48 hours. Subsequently, 5 µm sections of tissue paraffin were routinely prepared for staining with hematoxylin and eosin (Bancroft and Layton, 2019). The stained sections were inspected under a light microscope (Nikon E800 Eclipse) to evaluate histopathological changes, and photos were taken using a digital camera.

Data analysis

Survey responses were tabulated and analyzed to determine the frequency of different responses among preclinical and clinical students. Histopathological findings were described qualitatively, with the number of students observing each feature recorded for the lung tissue examination.

Result and Discussion

Survey results on awareness and understanding of OPA among veterinary students

The following Table 1 summarizes the responses from a survey conducted among 49 preclinical and 45 clinical-grade veterinary students. This survey assessed participants demographic information, knowledge regarding OPA, attitudes toward its diagnosis and management, and practical experiences with the disease.

The survey results indicate varying awareness and understanding of OPA among the participants. Most preclinical students reported minimal familiarity with OPA, with 46 students indicating uncertainty about its causative agents. In contrast, clinical-grade students exhibited a higher recognition of JSRV as the primary cause, with 40 respondents identifying it correctly.

Regarding attitudes toward the importance of early diagnosis, a significant number of clinical students (30) recognized it as very important, compared to only 19 preclinical students. However, both groups lack confidence in diagnosing OPA based solely on clinical signs, as reflected by the high number of students expressing not confident in their abilities.

Table 1: Survey results on awareness and understanding of OPA among veterinary students.

Survey question	Preclinical students (n=49)	Clinical students (n=45)
Section 1: Participant Information		
Total respondents	49	45
Section 2: Knowledge about OPA		
1. How familiar are you with ovine pulmonary adenocarcinoma (OPA)?		
- Not familiar at all	7	3
- Somewhat familiar	16	11
- Moderately familiar	23	24
- Very familiar	3	7
2. OPA is primarily caused by which virus?		
- Jaagsiekte sheep retrovirus (JSRV)	0	40
- Foot-and-mouth disease virus	2	1
- Bluetongue virus	1	2
- I don't know	46	2
3. In your opinion, which age group of sheep is most commonly affected by OPA?		
- 2-3 months	19	3
- 1-2 years	10	5
- 2-4 years	15	25
- I don't know	5	12
Section 3: Attitudes towards OPA diagnosis and management		
4. How important do you believe early diagnosis of OPA is for preventing its spread in a flock?		
- Not important	10	1
- Somewhat important	10	4
- Moderately important	10	10
- Very important	19	30
5. In your opinion, what is the most effective way to diagnose OPA in sheep?		
- Clinical signs and history	9	10
- Postmortem examination	10	14
- Serological tests	0	10
- Imaging (e.g., ultrasound)	10	10
- I don't know	20	1
Section 4: Practical experience		
6. Have you ever encountered or studied a case of OPA during your academic or professional career?		
- Yes	0	12
- No	49	33
7. If yes, how was the case diagnosed?		
- Postmortem examination	0	10
- Clinical signs	0	2
- Laboratory tests	0	0
- Other (please specify)	0	0
8. How confident are you in diagnosing OPA based on clinical signs alone?		
- Not confident	48	35
- Somewhat confident	1	5
- Confident	0	3
- Very confident	0	2

Table 2: *Case history inquiries made by veterinary students in the suspected case.*

Case history inquiry	Number of students asking
Duration of respiratory symptoms (e.g., coughing, labored breathing)	38
Previous respiratory illness or treatments	35
History of weight loss or decreased appetite	32
Exposure to other infected animals or herd history of disease	30
Vaccination and deworming history	28
Age and reproductive status of the sheep	27
Presence of nasal discharge or abnormal lung sounds	26
Recent changes in environmental conditions (e.g., housing, weather)	22
Antibiotic or other medication usage prior to illness onset	21
Travel history or movement between different herds	18

Table 3: *Postmortem observations made by veterinary students during the examination of sheep affected by chronic respiratory disease, arranged by the frequency of observations.*

Observation	Number of students observing
Enlarged lungs	44
Frothy fluid exuding from lung nodules	42
Gray nodules present on the cut surface of the lungs	35
Absence of lesions in the liver and kidneys	32
Lungs failing to collapse properly	30
No lesions in the mediastinal lymph nodes	28
Mucoid discharge observed in the pleural cavity	25

During the postmortem examination and diagnostic work-up of suspected OPA cases, veterinary students were encouraged to ask critical case history questions to enhance their understanding of disease presentation. As outlined in [Table 2](#), 38 students inquired about the duration of respiratory symptoms, such as coughing and labored breathing, as a key diagnostic element. This was closely followed by 35 students asking about any prior history of respiratory illness or treatments administered to the affected sheep.

Additionally, 32 students focused on understanding the history of weight loss or decreased appetite in the sheep, which are common clinical signs associated with OPA. Herd history and exposure to other infected animals were highlighted by 30 students, emphasizing the importance of considering herd-wide health issues in the diagnostic process. Further, 28 students sought information on the vaccination and deworming status, while 27 students inquired about the age and reproductive status of the affected animals, which are important factors in disease susceptibility.

Questions related to clinical signs, such as nasal discharge or abnormal lung sounds, were raised by 26 students. Environmental factors, such as changes in housing or weather, were considered relevant by 22 students. Moreover, 21 students asked about any recent antibiotic or medication use, which could influence disease progression or mask clinical signs. Finally, 18 students considered travel history or the movement of sheep between herds as potential factors influencing disease spread. These case history inquiries demonstrate the students' comprehensive approach to gathering vital information for diagnosing and managing OPA.

Postmortem observations noted by veterinary students during the examination of sheep with chronic respiratory disease case

During the postmortem examination of sheep exhibiting chronic respiratory distress, 45 undergraduate veterinary students documented their observations of various pathological features as outlined in [Table 3](#). The most frequently noted observation was enlarged lungs, identified by 44 students, indicating significant pulmonary involvement, likely associated

with chronic respiratory disease. Following this, frothy fluid exuding from lung nodules was reported by 42 students, which may suggest the presence of pulmonary edema or necrosis often linked to severe respiratory conditions. Additionally, gray nodules on the cut surface of the lungs were observed by 35 students, pointing towards possible neoplastic changes or granulomatous lesions. The absence of lesions in the liver and kidneys was noted by 32 students, suggesting that these organs may not have been adversely affected by the chronic respiratory condition. Lungs failing to collapse properly, noted by 30 students, may reflect a loss of elastic recoil or significant pleural involvement, which is common in cases of respiratory distress. Furthermore, no lesions in the mediastinal lymph nodes were observed by 28 students, indicating the absence of significant lymphadenopathy or metastasis. Lastly, mucoid discharge in the pleural cavity was documented by 25 students, which could be indicative of exudative processes or infection.

Histopathological observations of lung tissues with suspected OPA by veterinary students

The histopathological examination of lung specimens from sheep diagnosed with OPA yielded notable histological alterations, as summarized in Table 4. The observations recorded by 45 veterinary students highlight several key findings. A total of 35 students noted the proliferation of neoplastic cells within both alveolar and bronchial epithelial linings, which frequently manifested as papillary, solid, or acinar formations observed by 30 students.

Observations indicated that the proliferative neoplastic growths exert pressure on adjacent alveoli, resulting in their collapse and the enlargement of the neoplastic nodules, with 28 students reporting this finding. The

normal alveolar epithelial cells were observed to be replaced by cuboidal or columnar tumor cells, with 34 students acknowledging this significant alteration. Despite the presence of neoplastic changes, the overall architecture of the alveolar wall was preserved, as noted by 26 students.

Mitotic figures within the neoplastic cells were found to be sparse, with only 20 students observing this feature. The cytoplasm of cuboidal tumor cells appeared homogeneous and eosinophilic, while columnar tumor cells displayed distinct vacuolated spaces, a finding recorded by 15 and 32 students, respectively. Furthermore, the stroma surrounding the neoplastic nodules was reported to be infiltrated with mononuclear inflammatory cells, including plasma cells, macrophages, and lymphocytes, in addition to connective tissue fibers, with 33 students noting this infiltration.

Histopathological finding

Lung: Necropsy findings showed that the lungs were enlarged and had a firm texture, exhibiting a meaty appearance on the cut surfaces. There were multifocal to coalescent grayish-white nodules of varying sizes, typically embedded within the pulmonary parenchyma. Microscopic examination of the lung tissue affected by OPA indicated tumor nodules formed by one or more layers of neoplastic cells lining the alveolar walls. These cells exhibited a cuboidal or elongated morphology, frequently forming papillary projections, cystic patterns or arranged in cords within the alveolar spaces. Papillary formations were prominent within tumor foci, where alveolar macrophages were often observed within the adjacent alveoli, phagocytosing cellular debris. The neoplastic cells lining the alveoli appeared either cuboidal or columnar in shape. These cells demonstrated eosinophilic,

Table 4: *Histopathological observations of lung tissues in OPA by veterinary students.*

Histopathological finding	The number of students observing
Proliferation of neoplastic cells in alveolar and bronchial linings	35
Neoplastic nodules with papillary, solid, or acinar appearances	30
Pressure-induced collapse of adjacent alveoli due to neoplastic nodules	28
Replacement of normal epithelial cells by cuboidal or columnar tumor cells	34
Preserved general structure of alveolar walls	26
Sparse mitotic figures in neoplastic cells	20
Homogeneous eosinophilic cytoplasm in cuboidal tumor cells	15
Vacuolated cytoplasm in columnar tumor cells	32
Infiltration of stroma with mononuclear inflammatory cells and connective tissue fibers	33

homogeneous cytoplasm in cuboidal cells, whereas columnar cells exhibited a more pallid cytoplasm. The tumor structures were further organized into alveoli-like formations, characterized by thin bands of stromal tissue lined by these neoplastic cells. Additionally, there was a significant presence of mononuclear inflammatory

cells, especially lymphocytes and macrophages, surrounding the neoplastic lesions. Interstitial fibrosis, as well as prominent lymphoid nodules, were observed throughout the lung parenchyma. Occasionally, hyperplastic proliferation in the epithelial cell lining of the bronchioles was noticed (Figure 1A-L).

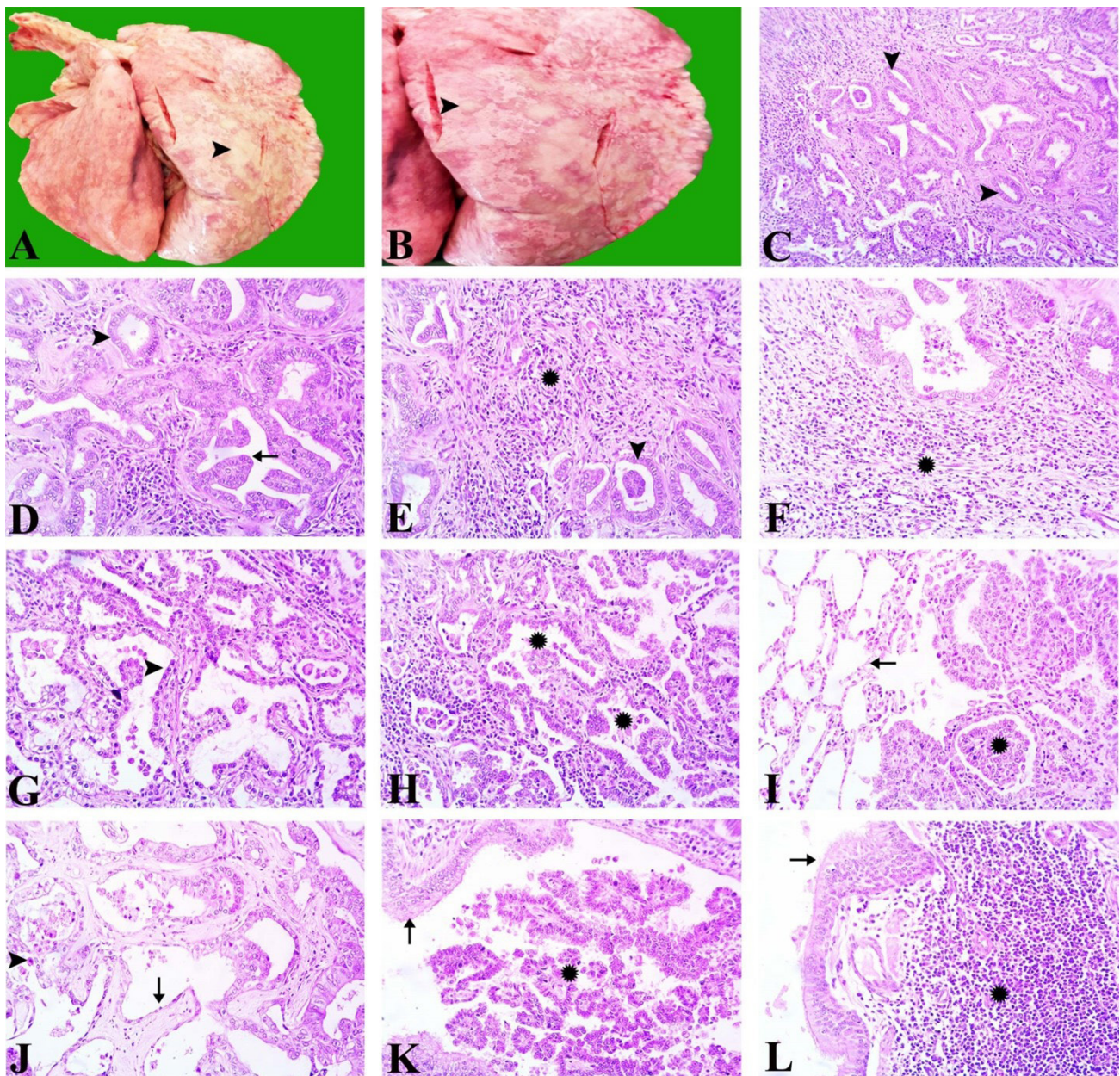


Figure 1: Representative photomicrograph of sheep lungs with adenomatosis. (A, B) Gross lesion showing voluminous, firm lungs with the presence of multifocal to coalescent grayish white, circumscribed nodules (arrowhead) of variable sizes embedded in the pulmonary tissue. (C-L) Microscopic lung sections stained with HandE (x200), (C) Neoplastic foci arising from the alveolar epithelium arranged in acinar pattern (arrowhead). (D) Tumor nodules composed of single to multiple layers of cuboidal to columnar neoplastic cells forming papillary projections (arrow), or cystic patterns (arrowhead). (E) Neoplastic alveoli (arrowhead) supported by fibrovascular stroma (asterisk) infiltrated with mononuclear inflammatory cells, especially lymphocytes and macrophages, surrounding the neoplastic lesions. (F) Interstitial fibrosis (asterisk) with leukocytes infiltration replacing large areas of pulmonary parenchyma. (G) Neoplastic alveoli lined with single to multiple layers of cuboidal to columnar neoplastic cells arranged in cords (arrowhead) within the alveolar spaces. (H) Neoplastic alveoli in different (cords or tubules or papillary) pattern with detached neoplastic mass (asterisk) within the alveolar spaces. (I) Tumor mass detached and completely occluded the lumen of alveoli (asterisk) along with adjacent pulmonary structure showing degenerative changes (arrow). (J) The tumor structures organized into alveoli-like formations, characterized by thin bands of stromal tissue lined by neoplastic cells (arrow) associated with presence of alveolar macrophages (arrowhead) within the adjacent alveoli. (K) Hyperplasia in the lining epithelium of the bronchiole (arrow) along with transformation of bronchial epithelium into papiliform growth almost completely filling the lumen (asterisk). (L) The bronchial epithelium shows hyperplasia (arrow) as well as prominent lymphoid nodules in the peribronchial area (asterisk).

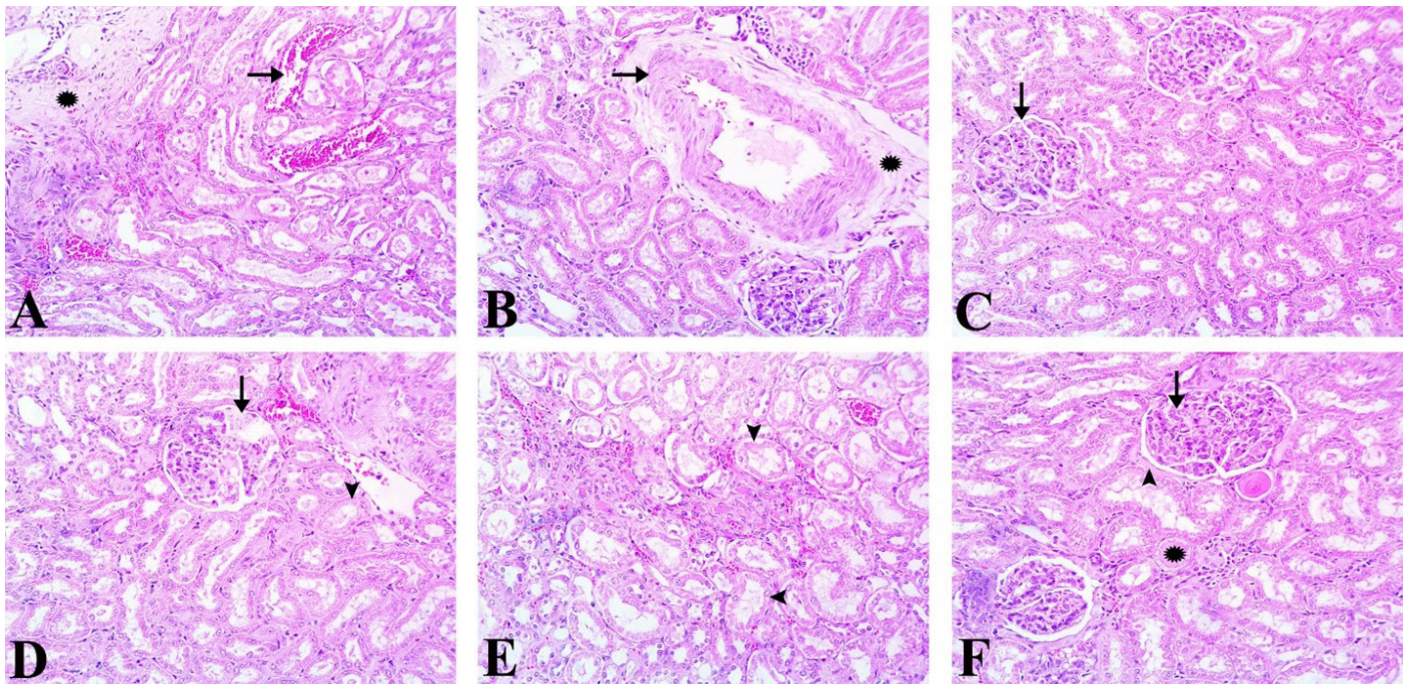


Figure 2: Representative photomicrograph of sheep kidney sections stained with HandE (x200). (A) Congestion and dilatation of the intertubular blood vessels (arrow) along with mild interstitial fibrosis (asterisk). (B) Vasculitis in renal blood vessels with thickening (arrow) and fibrosis (asterisk) of the blood vessels wall with mononuclear leukocytic infiltration. (C) Glomerular tuft hypercellularity and segmentation (arrow). (D) Glomerular tuft shrinkage (arrow) with degenerative changes in renal tubules (arrowhead). (E) Vacuolar degeneration with desquamation of the tubular epithelial cells (arrowhead). (F) Hypercellularity of the glomerular tuft with hyperplasia of mesangial cells (arrow), reduced Bowman's space, thickening, and hyalinization of Bowman's capsule (arrowhead) associated with hyaline casts in tubular lumina (asterisk).

Kidney: The renal tissue showed no signs of direct neoplastic infiltration; however, there were secondary changes associated with systemic illness, likely related to OPA. The renal blood vessels were congested, dilated, and filled with blood. Additionally, various degrees of vasculitis were observed, characterized by thickening and fibrosis of the vessel walls along with mononuclear leukocytic infiltration. Mild interstitial fibrosis was noted in the renal parenchyma, accompanied by moderate infiltration of mononuclear cells, primarily lymphocytes and macrophages. Some glomeruli displayed mild mesangial hypercellularity, tuft segmentation, and occasional thickening of Bowman's capsules. Shrinkage and atrophy of the tuft were also evident. While the tubular epithelial cells largely appeared intact, mild vacuolar degeneration and desquamation of the lining epithelial cells were seen in scattered tubules, along with the presence of hyaline casts, indicating early signs of systemic stress. No evidence of metastatic disease or direct involvement by the primary neoplasm was detected in the kidney (Figure 2A-F).

Liver: In the liver, the observed changes were mainly associated with chronic systemic inflammation. The hepatic tissue showed granulomas embedded within the hepatic parenchyma, characterized by a

granular eosinophilic caseated center surrounded by significant leukocytic infiltration, primarily consisting of lymphocytes and macrophages, and encased in a fibrous connective tissue capsule. Occasionally, bluish calcium granules were noted within the granulomas. The hepatic parenchyma displayed mild to moderate vacuolar degeneration in hepatocytes, with cytoplasmic vacuolization indicative of mild fatty changes. There was also focal infiltration of mononuclear cells, mainly lymphocytes and macrophages, in the portal tracts and occasionally around central veins. Periportal fibrosis and biliary hyperplasia were evident in some regions, suggesting a chronic inflammatory insult. The liver architecture remained largely intact, and no evidence of direct neoplastic infiltration was observed (Figure 3A-F).

Lymph node: Histological examination of the lymph nodes revealed a significant thickening of the capsule and trabeculae. The lymphoid follicles appeared less distinct, with a reduction in lymphoid populations. Lymph node atrophy was evident, characterized by a decrease in the number and size of follicles, with few or no germinal centers and reduced cellularity in the medullary cords, indicating lymphoid depletion. Multifocal areas of fibrosis were also observed. Additionally, dilated lymphatic channels were

identified, lined by lymphendothelium and filled with a light, lacy eosinophilic material likely representing lymph, which correlates with the chronic inflammatory

response associated with the neoplastic process in the lungs (Figure 4A-F).

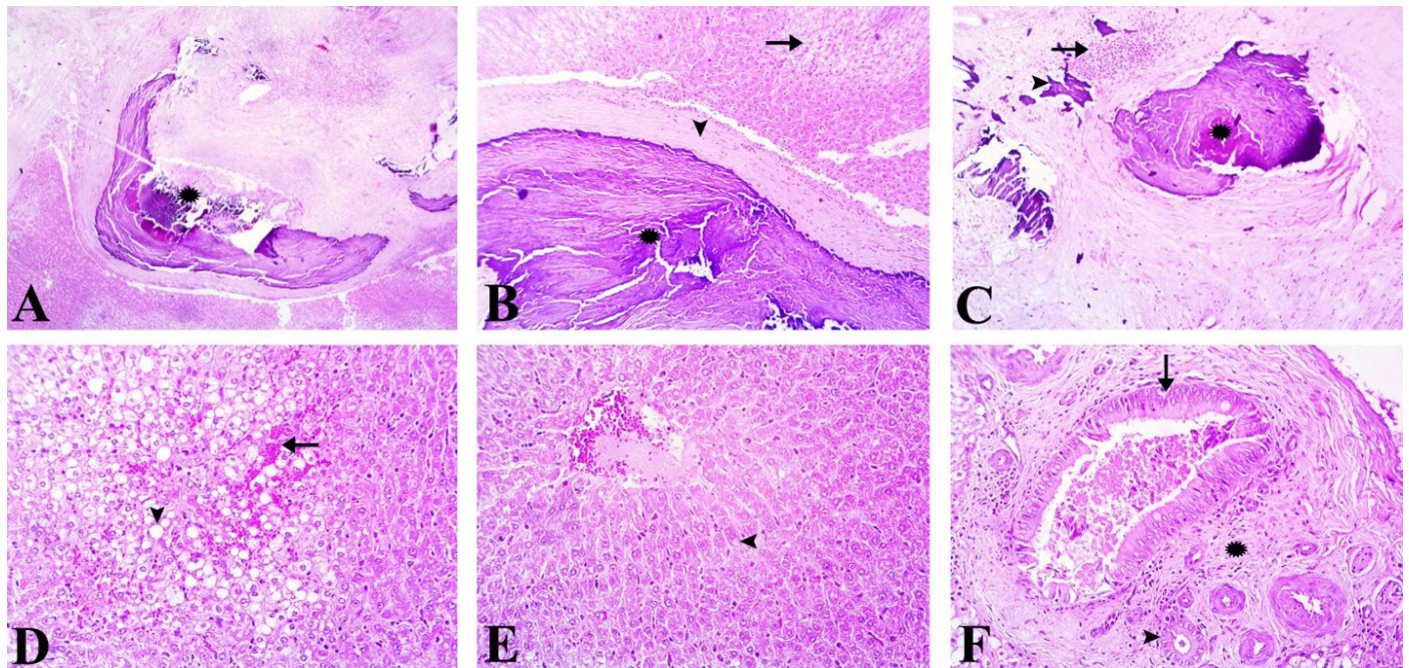


Figure 3: Representative photomicrograph of sheep liver sections stained with HandE. (A) The granuloma (asterisk) embedded in the hepatic parenchyma (x40). (B) The granuloma consists of granular eosinophilic caseated center (asterisk) enclosed by fibrous connective tissue capsule (arrowhead), adjacent hepatocytes showing clear fat vacuoles (arrow) (x100). (C) The granuloma consists of granular eosinophilic caseated center (asterisk) surrounded by massive leukocytic cellular infiltration (arrow) along with bluish calcium granules (arrowhead) scattered in the granuloma (x100). (D) Fatty degeneration of hepatocytes, characterized by discrete clear cytoplasmic vacuoles (arrowhead) associated with free RBCs scattered between degenerated hepatocytes (arrow) (x200). (E) Congestion and dilation of the central vein with vacuolar degeneration of hepatocytes (arrowhead) (x200). (F) Portal triad showing hyperplasia of biliary epithelium (arrow) with presence of eosinophilic debris in the bile duct lumina, newly formed bile ductules (arrowhead) associated with excessive fibrous connective tissue proliferation infiltrated with inflammatory cells (asterisk) (x200).

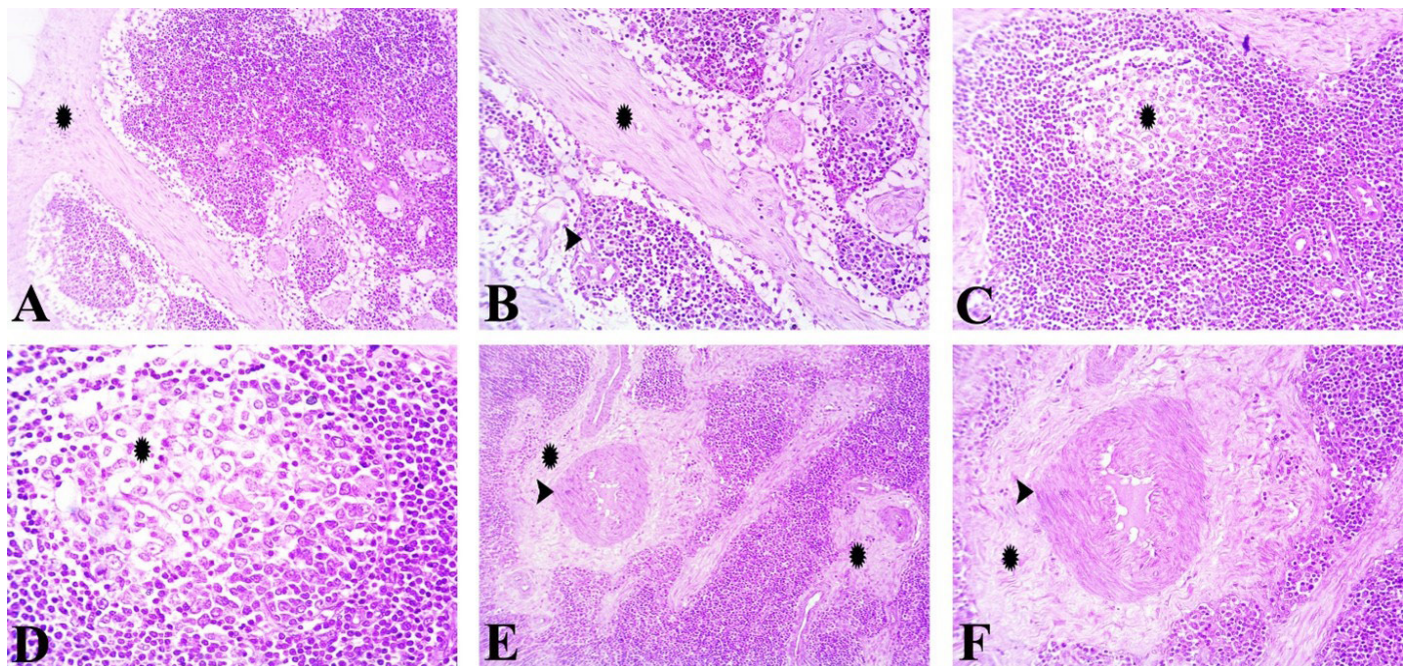


Figure 4: Representative photomicrograph of sheep lymph node sections stained with HandE. (A) Thickening in the capsule and trabeculae (asterisk) (x100). (B) Thickening in trabeculae (asterisk) with less distinct lymphoid follicle (arrowhead) (x200). (C) Lymphoid depletion (asterisk) (x100). (D) High power of previous figure, reduced number of lymphocytes in the germinal center (asterisk) (x200). (E) Dilatation of lymphatic channels (arrowhead) with multifocal fibrosis (asterisk) (x100). (F) Lymphatic channels showing marked thickening in their walls (arrowhead) and surrounded by excessive fibrous connective tissue proliferation (asterisk) (x200).

The present study provides a comprehensive assessment of OPA in sheep, encompassing both gross and histopathological findings, as well as an evaluation of veterinary students' awareness and understanding of the disease. The results highlight the complex nature of OPA and underscore the importance of thorough pathological examination in its diagnosis and characterization.

The macroscopic pathological features seen in this investigation, including enlarged lungs with gray nodules and frothy fluid exuding from lung nodules, are comparable with classical OPA lesions described in earlier study by [Griffiths et al. \(2010\)](#).

These features are symptomatic of the neoplastic transformation and enhanced fluid production associated with JSRV infection. The failure of the lungs to collapse adequately, observed by 30 students, fits with the loss of elasticity commonly seen in advanced stages of OPA ([Toma et al., 2020](#)).

Histopathological investigation revealed proliferation of neoplastic cells in alveolar and bronchial linings, forming papillary, solid, or acinar patterns. This observation is in line with recent findings by [Abdullah \(2023\)](#), who described similar histological patterns in OPA-affected sheep. The replacement of normal epithelial cells by cuboidal or columnar tumor cells, as noted in the present study, is a hallmark of OPA and reflects the virus-induced transformation of type II pneumocytes and Clara cells ([Martineau et al., 2011](#)).

The existence of mononuclear inflammatory cell infiltration in the stroma surrounding neoplastic nodules, as found in our work, suggests an ongoing immune response to the neoplastic process. This finding corroborates recent research by [Grego et al. \(2008\)](#), who reported similar inflammatory responses in OPA-affected lung tissues.

While the lungs showed the most significant pathogenic abnormalities, our investigation also found secondary changes in other organs. The systemic consequences of persistent inflammation and metabolic disturbances associated with advanced OPA may be responsible for the mild interstitial fibrosis and vacuolar degeneration observed in the kidneys and liver, respectively. These findings are consistent with those reported by [Minguijón et al. \(2013\)](#), who described similar extrapulmonary

changes in OPA-affected sheep.

The lymphoid depletion observed in lymph nodes is particularly noteworthy. This finding may reflect the immunosuppressive effects of JSRV infection, as suggested by recent studies ([Summers et al., 2006](#)). The potential impact of this immunosuppression on disease progression and susceptibility to secondary infections warrants further investigation.

The survey results revealed varying levels of awareness and understanding of OPA among veterinary students. The higher recognition of JSRV as the primary cause of OPA among clinical-grade students compared to preclinical-grade students underscores the importance of clinical exposure in enhancing disease knowledge. However, the overall lack of confidence in diagnosing OPA based on clinical signs alone highlights the need for improved education and training in this area.

Recent studies have emphasized the importance of integrating pathology education with clinical training to enhance veterinary students' diagnostic skills ([Krockenberger et al., 2007](#)). Our findings support this approach and suggest that exposure to gross and histopathological specimens of OPA could significantly improve students' ability to recognize and diagnose this important disease.

The complex pathological picture of OPA observed in this study underscores the challenges associated with its diagnosis, particularly in early stages. While postmortem examination remains a definitive diagnostic method, there is a pressing need for more sensitive and specific ante-mortem diagnostic techniques. Recent advancements in molecular diagnostics, such as the development of JSRV-specific PCR assays ([Lee et al., 2017](#)), provide promising methods for early detection and control of OPA in sheep flocks.

Furthermore, the potential role of OPA as a model for human lung adenocarcinoma, as suggested ([Gray et al., 2019](#)), highlights the broader implications of research in this field. Understanding the pathogenesis of OPA could provide valuable insights into the mechanisms of virus-induced carcinogenesis in both veterinary and human medicine. While this study provides valuable insights into the pathological features of OPA and student awareness of the disease, it has some limitations. The sample size for the pathological

examination was limited, and future studies with larger cohorts could provide more comprehensive data on the prevalence and distribution of OPA lesions. The acinar or papillary patterns of growth characteristic of OPA to be screened and differentiated from other caprine pulmonary tumors. Additionally, molecular techniques such as immunohistochemistry or in situ hybridization could offer further insights into the distribution of JSRV within affected tissues.

Future research should focus on developing and validating ante-mortem diagnostic techniques for OPA, as well as exploring potential therapeutic interventions.

Conclusion and Recommendations

In conclusion, this study provides a comprehensive overview of the pathological features of OPA and highlights the importance of thorough gross and histopathological examination in its diagnosis. The findings underscore the need for improved veterinary education on OPA and the development of more effective diagnostic and control strategies for this economically important disease in sheep.

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Novelty Statement

This study offers a novel assessment of ovine pulmonary adenocarcinoma by combining histopathological analysis and student awareness evaluation, emphasizing improved diagnostic approaches and early detection of JSRV infection in sheep.

Author's Contribution

Ibrahim Elmaghraby, Osama Ahmed, Shymaa Moustafa and Salma Shoulah: Writing original draft preparation, writing review and editing. All authors have read and agreed to the published version of the manuscript.

Ethical approval

This study was performed in strict accordance with the regulations and protocols authorized by the Ethics Committee of the Faculty of Veterinary Medicine, Benha University (Approval No. BUFVTM23-10-24).

Conflicts of interest

The authors have declared no conflict of interest.

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