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**RESEARCH ARTICLE**

# An Epidemiological Study on Neonatal Lamb Health [1]

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## Summary

This study involved 823 neonatal lambs born between March and July 2006 on four farms in Kars. Health problems were identified on daily visit by authors and management practices were determined by questionnaire and on these visits. Causes of morbidity and mortality were defined separately based on clinical and pathological findings. The overall morbidity rate was 48.6%. The morbidity rate of diarrhoea, lameness, navel infections, pneumonia, Weak Lamb Syndrome (WLS), Fatigue Anorexia Syndrome (FAS), birth stress, abdominal mass, mismothering and trauma were 15.4%, 5%, 4%, 3.5%, 3.3%, 3.3%, 2.8%, 2.3%, 2.2% and 1.1%, respectively. The proportion of lambs died during neonatal period was 20.8%. The mortality rate for WLS, birth stress, abdominal mass, diarrhoea, FAS, mismothering and trauma were 3.2%, 2.8%, 2.2%, 1.9%, 1.7%, 1.3%, and 1.1%, respectively. According to necropsy, the mortality rates of premature birth, birth stress, trauma, trichobezoar, starvation, septicaemia, omphalitis, clostridial infection and white muscular disease were 3.2%, 2.7%, 2.3%, 2.3%, 2.2%, 1.9%, 1.1%, 1.2% and 0.7%, respectively. Non-infectious reasons were dominant in mortality while infectious reasons were commonly associated with morbidity ($P<0.001$). Health problems were mainly determined in first two weeks of life apart from respiratory problems and abdominal mass. More than 50% of lamb losses occurred within first week of life. Failure of passive transfer was determined in 19.2% of diseased lambs. Use of hay/straw as bedding, disinfecting and shorter interval of cleaning pen, observation during lambing, vaccination of ewes and providing sufficient feeding were significantly associated with decreased risk of morbidity ($P<0.05$). The results revealed that a significant number of lamb contracted disease and died in neonatal period and that management faults played a role. These findings imply that maximum care should be exercised during neonatal period to increase farm profitability.

**Keywords:** *Neonatal lamb, Morbidity, Mortality, Risk factors*

# Neonatal Kuzu Sağlığı Üzerine Epidemiyolojik Bir Çalışma

## Özet

Bu çalışmada Kars bölgesindeki 4 çiftlikte Mart ile Temmuz 2006 arasında doğan 823 neonatal kuzu incelendi. Sağlık problemleri günlük yapılan ziyaretlerle araştırıcılar tarafından tespit edildi ve sevk-idare uygulamaları ise anket ve bu ziyaretler esnasında belirlendi. Morbidite ve mortalite sebepleri klinik ve patolojik olarak belirlendi. Total morbidite oranı %48.6 olarak belirlendi. İshal, topallık, göbek enfeksiyonu, pnömoni, Zayıf Kuzu Sendromu (ZKS), Halsizlik Anoreksi Sendromu (HAS), doğum stresi, abdominal kitle, Zayıf Annelik İçgüdüsü (ZAİ) ve travmadan kaynaklı morbidite oranları sırasıyla %15.4, %5, %4, %3.5, %3.3, %3.3, %2.8, %2.3, %2.2 ve 1%.1 olarak belirlendi. Neonatal mortalite oranı %20.8 olarak belirlendi. ZKS, doğum stresi, abdominal kitle, ishal, HAS, ZAİ ve travmadan kaynaklı mortalite oranları sırasıyla %3.2, %2.8, %2.2, %1.9, %1.7, %1.3 ve %1.1 olarak belirlendi. Nekropsiye göre prematüre doğum, doğum stresi, travma, trikobezoar, açlık, septisemi, omfalitis, klostridiyal infeksiyon ve beyaz kas hastalığının sırasıyla %3.2, %2.7, %2.3, %2.3, %2.2, %1.9, %1.1, %1.2 ve %0.7 oranlarında ölüme yol açtığı belirlendi. Mortalitede non-infeksiyöz nedenler, morbiditede ise enfeksiyöz nedenler daha dominant bulundu ($P<0.001$). Pnömoni ve abdominal kitle olguları dışında neonatal kuzu hastalıklarının çoğunlukla ilk iki hafta içerisinde gerçekleştiği belirlendi. Kayıplar ise %50'den fazla oranda ilk hafta içerisinde gerçekleşti. Hasta kuzuların %19.2'sinde pasif transfer yetmezliği belirlendi. Altlık olarak ot/saman kullanımı, kuzu padoklarının dezenfeksiyonu ve temizleme aralığı, kuzulama zamanında gözlem, koyunların aşılanması ve yeterli besleme gibi sevk-idare uygulamalarının morbidite riskini azalttığı belirlendi ($P<0.05$). Çalışmamızda neonatal kuzuların büyük oranda sağlık problemine maruz kaldığı ve öldüğü ve sevk-idare uygulamalarının bunda önemli rol oynadığı ortaya konuldu. Bu bulgular, çiftlik verimliliğini arttırmak için neonatal dönemin azami ilgi gerektirdiğini göstermektedir.

**Anahtar sözcükler:** *Neonatal kuzu, Morbidite, Mortalite, Risk faktörleri*

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## INTRODUCTION

Economical losses due to neonatal lamb morbidity and mortality are a matter of serious concern for sheep farmers [1-3]. This is clearly so when the animal rearing is the sole economical activity as in Kars, Turkey [4]. Farmer education, better management practices and adequate veterinary services may avoid such losses. However, reports from other parts of the world still point out great lamb losses despite improvement in management, veterinary services and farmer's knowledge [2,5]. This is partly due to the physiological state in which lambs are in neonatal period as lambs are born physically and immunologically vulnerable to infectious and environmental effects. Therefore, disorders and their fatal consequence are frequently encountered in this period of life [1,3,6,7].

Studies have already reported morbidity and mortality rates of 1.6-86.8% [8-10] and 3.2-63% in neonatal period respectively [1,5-8,11-16] and mortality rates of %2-68 in lambs of different age period [3,17-21]. Non-infectious diseases such as starvation (Starvation Mismothering Exposure -SME- complex), trauma, birth stress, hypothermia are commonly reported in the first two weeks while infectious diseases mainly encountered in the last two weeks of neonatal period. Mortality due to non-infectious causes is reported to be higher than that of infectious causes [1,2,6,22]. This implies the importance of improved farm management practices.

Risk factors associated with lamb morbidity and mortality have extensively been studied and they have been gathered under four major categories; 1) farm management practices, 2) environmental factors, 3) sheep and 4) lamb related factors but their effects are not independent of each other [1,13]. Risk factors identified were as fallow; age of dam, dam-lamb interaction/relationship (lamb behavioral disorders, mismothering), birth weight, feeding, housing, lambing pen and hygiene, accumulation of lambs in the pen, lambing type, observation during lambing, lamb activity, udder health, immune status of dam and environmental conditions [3,11,19-24].

Although improvements in management and husbandry have been achieved in many countries, mortality rates in neonatal lambs reported to be between 10 and 35% [2,17]. This may be attributed to improperly prepared or inadequately applied control strategies due to methodological variations in scientific research on which these strategies have been based. Epidemiological studies involving lamb morbidity and mortality varied in terms of methodology used; farm visits were either weekly or fortnightly [9,15,25], data were gathered from only vets, farmers, diagnostic laboratories [9,13,21,26], pathological examinations [1,7,12,13,27,28] or questionnaires [19,29], studies involved only one farm [16,23] or a part of a flocks [9], case definitions and period of lamb life included also differed from study to study. Studies directed at determining morbidity in neonatal lambs are also scanty [8-10,26]. These short comings might have resulted in inadequate evaluation of the data giving rise to improper preventive measures leading to higher mortality rates.

All these facts led us to design an epidemiological study aimed at determining lamb morbidity and mortality in Kars, Turkey where no such study had previously been conducted.

## MATERIAL and METHODS

This was a longitudinal study involving 4 sheep farms located in Kars central, Cağlayan, Halefoğlu and Kümbetli (labelled with letters in the text for confidentiality). The study comprised a lambing season between March and July 2006. The farms selection was based on farmer's cooperation, distance, number of ewes (above 100) and facilities which made conduction of the study easy. Farms were visited between September and December, 2005 by authors to explain the procedures involved. On the start of lambing, farms were daily visited to determine neonatal health problems. Each lamb was fallowed 4 weeks in this study.

Health problems were diagnosed based on clinical examinations and necropsy. Case definitions and their necropsy findings are given in the *Table 1*. Health problems were also categorised as infectious (enteritis, pneumonia, pneumo-enteritis, navel infections or omphalitis, clostridial infections), non-infectious (birth stress, trauma, starvation due to hypothermia and mismothering, abdominal mass caused by trichobezoar, lameness, congenital abnormality) and others (Weak Lamb Syndrome-WLS, nervous symptoms and coma-shock whose underlying causes were not diagnosed clinically or

***Table 1.*** *Common causes of health problems in neonatal lambs with the indication of age and the most evident clinical and necropsy signs (including our findings)*
***Tablo 1.*** *Neonatal kuzularda karşılaşılan yaygın sağlık problemlerinin görüldüğü yaş ve belirgin klinik ve nekropsi bulguları (çalışma bulgularımızı da kapsamaktadır)*

| Causes | Age | Clinical Symptoms | Necropsy findings | References |
|---|---|---|---|---|
| **Abortion** | Expulsion of foetus before 130 days of gestation | The expulsion of a foetus that has reached a recognisable size but not capable of independent life (non-viable foetus) | Moderate to advanced autolysis (red stained tissues and transudates),<br>Putrefaction,<br>Mummification | 7,32 |
| **Stillbirth** | Expulsion of foetus after 142 day of gestation | The expulsion of a foetus after it has attained capacity for independent life (viable foetus).<br>Lambs are born at term, but without any signs of life | Atalectic lungs and mucous filled trachea,<br>Generalised red stained subcutaneous oedema,<br>Decomposition of carcases and foul smell,<br>Fluid in the abdomen,<br>Varying degrees of autolysis present in kidney and livers | 7, 22, 32-34 |
| **Weak Lamb Syndrome (WLS)** | Birth between 130 and 140 days of gestation.<br>Lambs are alive in first few days of life | Lambs are born alive but weak and having difficulty in standing up, moving, in-coordination, underdevelopment and loss of sucking reflex<br>Premature lambs born susceptible to many problems (trauma, hypothermia, starvation) | Premature lambs with unerupted teeth, soft hoof | 6,16,22,32 |
| **Birth Stress (Dystocia and Prolonged birth)** | Deaths occurring during or within 3 hours of birth | Intervened birth or prolonged birth process leading to asphyxia and/or trauma associated with lesions on foetal CNS during the vaginal birth<br>Lamb may sometimes walk and discharge meconium but have weakness, anorexia, hypothermia, starvation and trauma | Generally fresh carcase,<br>Localized oedema of subcutaneous tissues around head, forelimbs, tail and perineum, oedema formed in this manner is colourless,<br>Bruising of various tissues, especially the head and neck,<br>The skin and birth coat are frequently meconium-stained,<br>The lungs are slightly to completely inflated and congestion of the mucosa of the trachea is present,<br>Notable epidural and subdural haemorrhages exist around brain and spinal cord, congestion and haemorrhages within the meninges are apparent (usually these animals have severe central nervous system haemorrhage particularly in cranial area),<br>Rupture of the liver or liver capsule with haemorrhage causing a large blood in the abdominal cavity,<br>Subpleural, subepicardial, subendocardial haemorrhages, petechiae and echymoses | 12,22, 33-35 |
| **Starvation, hypothermia and mismothering (SME complex)** | 1-5 hours post parturient (secondary starvation and hypothermia occur 10 hours after birth) | Inadequate or no colostrum and/or milk intake,<br>Hypothermia or low temperature (34-35°C),<br>Wet coat, weakness, anorexia, incapable of moving and standing,<br>Exhaustion,<br>Mismothering, orphanage, sometimes dullness and unconsciousness,<br>Meconium voided,<br>Aberrant maternal or neonatal behaviour,<br>Loss of mobility | Absence of milk in the alimentary tract and food has not passed beyond the small intestine,<br>Loss of fat deposits and body mass is common,<br>Varying degree of brown fat catabolism, particularly around the kidneys and in the pericardium, from white cream to red brown and gelatinous texture,<br>Subcutaneous oedema often occurs in the distal limbs and less frequently at the base of the tail, face, muzzle and ears (“peripheral oedema”),<br>Lungs are not atelectic,<br>Large intestine contains meconium | 1-3,6,7,22, 33-36 |
| **Fatigue-Anorexia Syndrome (FAS)** | Birth onward | Lambs are born normal but signs appear afterwards including difficulty in standing, anorexia, partial or complete loss of sucking reflex, depression, incoordination, staggering and pain | Starvation, infections (omphalitis, enteritis, pneumonia), white muscle disease and trichobezoar determined on necropsy | 2,25 |

***Table 1.*** *Continued...*
***Tablo 1.*** *Devam...*

| Causes | | Age | Clinical Symptoms | Necropsy findings | References |
|---|---|---|---|---|---|
| **Nervous symptoms** | | Birth onward | Incoordination, tremors, twitching, circling, running into fence or walls | Cavitations in the cerebral hemispheres and white matter, cerebellar atrophy and no specific lesions in some cases in our study | 9,36 |
| **White Muscle Disease (WMD)** | | Birth onward | General weakness, sudden death, weakness in hind limbs, recumbency, incoordination | Fluid-filled cavitations in the cerebral hemispheres, cavitations in the white matter, disappearance of the septum pellicidum, mild or moderate cerebellar atrophy. Subendocardial circumscribed, whitish plaques in the ventricles due to necrosis and calcification of the myocardium and skeletal muscles | 22,30,35 |
| **Coma-Shock** | | Birth onward | Weak lamb, off feed, depressed, fever, diarrhoea, pneumonia, recumbency, severe depression, unresponsive to stimulus, incoordination, convulsion, dyspnea, dullness, unconsciousness, sleep, drowsiness, pain, poor vital functions | Clostridial infection, omphalophlebitis, septicaemia, starvation | 9,25,36 |
| **Lameness (Joint disease)** | | >3 days of parturition | Lame, swollen joint, pain and fever in joints, interdigital abscess, incoordination | Secondary starvation | 35 |
| **Trauma** | | Birth onward | History, specific lesion (wounds etc.), drowning, pain, incoordination, sudden death | Disruption of physical and physiological integrity of organs and tissues | 1,7,34 |
| **Infections** | Diarrhoea (scours) | >12 hours of parturition | Watery defecation exceeding 12 hours, dehydration requiring treatment (some cases), weakness, fever (some cases), sudden death, blood stained scour | Signs of inflammation in at least two organs (intestines and lungs), haemorrhagia, petechial and echymotic haemoragia, oedema, congestion in organs and tissues, serous or sero-haemoraggic fluid in body cavities, enteritis,septicaemia | 9,25,35,36 |
| | Pneumonia | >5 days of parturition except for inhalation pneumonia | Abnormal lung sounds, dyspnoea, laboured breathing, nasal discharge, fever or no fever, off feed, weakness | | |
| | Pneumonia-enteritis | >5 days of parturition | Signs of diarrhoea and pneumonia together | | |
| | Clostridium | >24 hours of parturition | Signs of diarrhoea, FAS, sudden death, coma-shock | Congestion and haemoragia in abomasums and intestinal mucosa, gas filled small intestine containing yellow-green fluid, fluid in abdominal cavity, pulpy kidney, hydropericardium with fibrin clots, gangrene around the umblicus, localised and generalised serofibrinous peritonitis, darkening of subcutis, necrosis and crepitating nodules around the abomasums | 9,25,36 |
| | Navel infections | >3 days of parturition | Swollen, abnormal discharge, heat in navel and surroundings, pain systemic fever in some cases | Abscess first in umbilical cordon then dispersing to liver, peritoneum and other internal organs | 19,35,37 |
| **Abdominal mass** | | >2 weeks of parturition | Bloat, colic, anorexia, abdominal mass and pain on palpation, decreased frequency of defecation and pica in some cases | Trichobezoar in the abomasum and intestine, blocking pyloris causing abomasal impaction | 8,14,36 |
| **Congenital deformation** | | Birth | According to defect.<br>Many defects, eg, organ agenesis, hydrocephalus, congenital defect of the skeletal system (torticollis), undershot jaw | Hydrocephalus, cavitations in the cerebral hemispheres, cerebellar atrophy, porencephaly,<br>Secondary starvation | 6,35,37 |
| **Undetermined diagnosis** | | Birth onward | No signs | Clostridial enterotoxemia, trauma, WMD or lambs having no pathological lesions or no diagnosis | 25 |

by necropsy). Enteritis, pneumonia, pneumo-enteritis cases were regarded as septicaemia and omphalitis and its complications such as omphalo-phlebitis, omphalohepatitis were regarded as omphalitis on necropsy.

Failure of passive transfer (FPT) was assessed in total of 88 lambs (73 diseased and 15 healthy lambs) using glutaraldehyde test [30] Farm management practices were obtained using pre-tested questionnaire and observations by authors on visits.

### *Data Analyses*

All data gathered by questionnaire, observations, clinical examinations and necropsy were coded and loaded on to a database using microsoft access and analysed using Epi Info 6. Neonatal lamb morbidity, mortality, case fatality and proportional mortality rates were calculated for each health problem using number of cases and deaths and total number of lambs born alive in 2006 lambing season [7,31]. Abortions and stillbirths were not included in these analyses. Yates corrected chi square ($x^2$) test was used to compare the proportions and to determine the effect of evaluated risk factors on morbidity rates [24]. Age of lamb was categorised as 1st, 2nd, 3rd and 4th week and chi square for trend was used to determine the effect of each score. Population density was defined as number of lambs divided by square mater of pens [24]. The significant level was set at $P<0.05$. Sick animals were subjected to treatment by a veterinarian on advice by authors on the view of ethical and humanitarian reasons.

## RESULTS

### *Farm Characteristics*

Number of ewes in farm A, B, C and D were 132, 402, 210 and 175 respectively. The breeds were Akkaraman, Morkaraman and their cross-breeds. Primiparous (first parity) ewes were present only on farm B (200 ewes) and farm D (75 ewes). The husbandry system was extensive in spring and summer and intensive in autumn and winter. Ewes were fed forages such as hay and straw on all farms and additionally concentrates (commercial and grain) on farms B, C and D during housing period while animals grazed pasture during outdoor period on all farms and no additional feed was supplied during this period.

Indoor period in A, B, C and D farms were 6, 7, 7 and 6 months, respectively. Indoor period was between October and April in farm B and C and between November and April in farm A and D.

Lambing took place in the shed where sheep were housed because none of the farm had lambing paddocks. Lambing time was not determined beforehand in all farms. Lambing was monitored in only farm B. Navel treatment was not performed and colostrums intake was not controlled in all farms. Adequate vitamin-mineral supplementation was performed on only farms A and B. Orphan lambs were fostered on only farm B. No vaccine was used in lambs on all farms except for farm B where clostridial vaccines were used. Lambs' pen were situated within the shed where ewes were also sheltered and hay/straw was used as bedding on only farm B. Lambs' pen was cleaned and disinfected once a week on farm B and at longer interval (above a week) on the other farms.

### *Morbidity and Mortality*

A total 919 ewes were present on the farms. Of these, 861 (93.7%) were pregnant and monitored. The percentage of abortion was 8.7% (75/861). After exclusion of abortion a total of 851 lambs born and 28 (3.3%) of the lambs were stillbirth, leaving 823 alive lambs to be followed up.

The proportion of lambs having at least one health problem during neonatal period was 48.6%. The most common problems were diarrhoea, lameness, navel infections, pneumonia, WLS, FAS, birth stress, abdominal mass, mismothering and trauma. Morbidity due to infectious reasons was significantly higher ($P<0.001$) *(Table 2)*.

The proportion of lambs died during neonatal period was 20.8% when abortion and stillbirth were included the losses reached up to 29.7%. Common clinical causes of mortality were WLS, birth stress, abdominal mass, diarrhoea, FAS, mismothering and trauma. Mortality rates due to non-infectious reasons were significantly different ($P<0.001$). Overall case fatality rate was 43%. The highest case fatality rates were determined for WLS, FAS, mismothering, abdominal mass, nervous symptoms but all cases of hypothermia, birth stress, coma-shock, trauma, congenital abnormality and unknown reasons died. The case fatality rate of non infectious reasons were markedly higher than that of infectious reasons

(P<0.001). Proportional mortality rates of WLS, diarrhoea, birth stress, FAS, mismothering, trauma, abdominal mass, lameness and unknown reasons were higher. Proportional mortality rate due to non-infectious reasons were also significantly higher (P<0.001) *(Table 2)*. Distribution of morbidity and mortality according to the farms is given in *Table 3*, the proportions significantly differed among the farms (P<0.001) as the lowest morbidity was in farm D and the highest was in farm A. Morbidity of infectious causes differed from farm to farm and the proportion was higher than that of non-infectious causes within the farms *(Table 3)*.

***Table 2.*** *Neonatal health problems determined on four sheep farms in Kars*
***Tablo 2.*** *Kars bölgesindeki dört çiftlikte belirlenen neonatal kuzu problemleri*

| Clinical Diagnose | Morbidity % (n1=823) | Mortality % (n1=823) | CFR % | PMR % (n2=172) |
|---|---|---|---|---|
| WLS | 3.3 (27) | 3.2 (26) | 96.3 (26/27) | 15.1 (26) |
| Diarrhea | 15.4 (127) | 1.9 (16) | 12.6 (16/127) | 9.3 (16) |
| Birth stress | 2.8 (23) | 2.8 (23) | 100 (23/23) | 13.4 (23) |
| FAS | 3.3 (27) | 1.7 (14) | 51.9 (14/27) | 8.1 (14) |
| Mismothering | 2.2 (18) | 1.3 (11) | 61.1 (11/18) | 6.4 (11) |
| Coma-shock | 0.5 (4) | 0.5 (4) | 100 (4/4) | 2.3 (4), |
| Trauma | 1.1 (9) | 1.1 (9) | 100 (9/9) | 5.2 (9) |
| Abdominal mass | 2.3 (19) | 2.2 (18) | 94.7 (18/19) | 10.5 (18) |
| Nervous symptom | 0.5 (4) | 0.4 (3) | 75 (3/4) | 1.7 (3) |
| Lameness | 5 (41) | 0.9 (7) | 17.1 (7/41) | 4.1 (7) |
| Congenital abnormality | 0.5 (4) | 0.5 (4) | 100 (4/4) | 2.3 (4) |
| Pneumo-enteritis | 0.85 (7) | 0.24 (2) | 28.6 (2/7) | 1.2 (2) |
| Pneumonia | 3.5 (29) | 0.12 (1) | 3.4 (1/29) | 0.6 (1) |
| Navel infectious | 4 (33) | 0.7 (6) | 18.2 (6/33) | 3.5 (6) |
| Hypothermia | 0.24 (2) | 0.24 (2) | 100 (2/2) | 1.2 (2) |
| Undetermined | 3.2 (26) | 3.2 (26) | 100 (26/26) | 15.1 (26) |
| Infectious | 23.8 (196) | 3 (25) | 12.8 (25/196) | 14.5 (25) |
| Non-infectious | 14 (116) | 9 (74) | 63.7 (74/116) | 43 (74) |
| Other | 10.6 (88) | 9 (73) | 83 (73/88) | 42.4 (73) |
| **Total** | **48.6 (400)** | **20.8 (172)** | **43 (172/400)** | **-** |

**CFR:** case fatality rate, **PMR:** proportional mortality rate **n1:** number of lambs examined, **n2:** number death lambs

***Table 3.*** *Distribution of morbidity and mortality rates in neonatal lambs according to farms*
***Tablo 3.*** *Neonatal kuzularda belirlenen morbidite ve mortalite oranlarının çiftliklere göre dağılımı*

| Hastalık | Farm A % (n=79) | | Farm B % (n=353) | | Farm C % (n=197) | | Farm D % (n=194) | | Statistics | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Morbidity | Mortality | Morbidity | Mortality | Morbidity | Mortality | Morbidity | Mortality | Morbidity | Mortality |
| WLS | 0 (0) | 0 (0) | 6.0 (21) | 5.7 (20) | 1 (2) | 1 (2) | 2.1 (4) | 2.1 (4) | P=0.002 | P=0.003 |
| Diarrhea | 19 (15) | 6.3 (5) | 12.8 (45) | 1.7 (6) | 25.4 (50) | 2.5 (5) | 8.8 (17) | 0 (0) | P<0.001 | P=0.006 |
| Birth stress | 10.1 (8) | 10.1 (8) | 1.4 (5) | 1.4 (5) | 2 (4) | 2 (4) | 3.1 (6) | 3.1 (6) | P<0.001 | P<0.001 |
| FAS | 8.9 (7) | 3.8 (3) | 1.9 (7) | 1.4 (5) | 5.1 (10) | 1.5 (3) | 1.5 (3) | 1.5 (3) | P=0.003 | P=0.003 |
| Mismothering | 5.1 (4) | 5.1 (4) | 2.5 (9) | 0.8 (3) | 1.5 (3) | 1 (2) | 1 (2) | 1 (2) | P=0.2 | P=1.7 |
| Coma-shock | 5.1 (4) | 5.1 (4) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | P<0.001 | P<0.001 |
| Trauma | 0 (0) | 0 (0) | 0.9 (3) | 0.9 (3) | 1.5 (3) | 1.5 (3) | 1.6 (3) | 1.5 (3) | P=0.6 | P=0.6 |
| Abdominal mass | 3.8 (3) | 3.8 (3) | 0.9 (3) | 0.6 (2) | 1 (2) | 1 (2) | 5.7 (11) | 5.7 (11) | P<0.001 | P<0.001 |
| Nervous symptoms | 0 (0) | 0 (0) | 1.1 (4) | 0.9 (3) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | P=0.15 | P=0.2 |
| Lameness | 0 (0) | 0 (0) | 6.2 (22) | 0.3 (1) | 8.6 (17) | 2.5 (5) | 1 (2) | 0.5 (1) | P<0.001 | P=0.03 |
| Con. Abnormality | 0 (0) | 0 (0) | 1.1 (4) | 1.1 (4) | 0 (0) | 0 (0) | 0 (0) | 0.0 (0) | P=0.15 | P<0.14 |
| Pneumo-enteritis | 0 (0) | 0 (0) | 1.1 (4) | 0.3 (1) | 0 (0) | 0 (0) | 1.5 (3) | 0.5 (1) | P=0.28 | P=0.7 |
| Pneumonia | 1.3 (1) | 0 (0) | 1.7 (6) | 0 (0) | 3.1 (6) | 0 (0) | 8.3 (16) | 0.5 (1) | P<0.001 | P=0.3 |
| Navel infections | 7.6 (6) | 1.3 (1) | 3.7 (13) | 0.3 (1) | 3.5 (7) | 1 (2) | 3.6 (7) | 1 (2) | P=0.4 | P=1.7 |
| Hypothermia | 1.3 (1) | 1.3 (1) | 0 (0) | 0 (0) | 0.5 (1) | 0.5 (1) | 0 (0) | 0.0 (0) | P=0.15 | P=0.15 |
| Undetermined | 5.1 (4) | 5.1 (4) | 1.4 (5) | 1.4 (5) | 6.1 (12) | 6.1 (12) | 2.6 (5) | 2.6 (5) | P=0.02 | P<0.4 |
| Infectious | 27.8 (22) | 7.6 (6) | 19.3 (68) | 2.6 (8) | 31.9 (63) | 3.5 (7) | 22.1 (43) | 2.1 (4) | P=0.006 | P=0.06 |
| Non-infectious | 20.2 (16) | 20.3 (16) | 13 (46) | 5.1 (18) | 15.2 (30) | 8.6 (17) | 12.4 (24) | 11.8 (23) | P=0.3 | P<0.001 |
| Others | 18.9 (15) | 13.9 (11) | 10.8 (37) | 9.3 (33) | 12.2 (24) | 8.6 (17) | 6.2 (12) | 6.2 (12) | ND | ND |
| **Total** | **67.1 (53)** | **41.7 (33)** | **42.78 (151)** | **16.7 (59)** | **59.4 (117)** | **20.8 (41)** | **40.7 (79)** | **20.1 (39)** | **P<0.001** | **P<0.001** |

**n:** number of lambs, **ND:** not done

The proportion of mortality also significantly differed among the farms (P<0.001) as the lowest mortality was in farm B and the highest was in farm A. The proportion of infectious and non-infectious causes of mortality differed among the farms and the rate of infectious causes was lower than that of non-infectious within the farms *(Table 3)*.

***Table 4.*** *Causes of mortality determined on necropsy examination*
***Tablo 4.*** *Nekropsi incelemelerine gore mortalite nedenleri*

| Diseases by necropsy | Mortality % (n1=823) | PMR (n2=161) |
|---|---|---|
| Septicemia | 1.9 (16) | 9.9 (16) |
| Starvation | 2.2 (18) | 11.2 (18) |
| Premature Birth | 3.2 (26) | 16.2 (26) |
| Omphalitis | 1.1 (9) | 5.6 (9) |
| Birth Stress | 2.7 (22) | 13.7 (22) |
| Trauma | 2.3 (19) | 11.8 (19) |
| Trichobezoar | 2.3 (19) | 11.8 (19) |
| Clostridia infections | 1.2 (10) | 6.2 (10) |
| White Muscle Disease | 0.7 (6) | 3.7 (6) |
| Undefined Neasons | 1.9 (16) | 9.9 (16) |
| Infectious* | 4.3 (35) | 21.7 (35) |
| Non-Infectious* | 10.2 (84) | 52.2 (84) |
| Other | 5. 1 (42) | 26.1 (42) |
| **Total** | **19.56 (161)** | **100 (161)** |

***** Significant difference- P<0.001, **n1:** Number of live lambs, **n2:** Number of lambs necropsied, **PMR:** Proportional mortality rate

### *Evaluation of necropsy results*

Of the 172 cases died during neonatal period 161 were subjected to post-mortem examination. The common reasons of mortality were premature birth, birth stress, trauma, trichobezoar, starvation, septicaemia, omphalitis, clostridial infection and WMD. Losses due to non-infectious reasons were significantly higher (P<0.001) *(Table 4)*.

Necropsy results of clinical cases are given in the *Table 5*. Deaths due to FAS resulted from infections, WMD, starvation, omphalitis and trichobezoar. WLS cases were associated with premature births. Cases of abdominal mass were caused by trichobezoar *(Table 5)*.

Diarrhoea was mainly caused by septicaemic reasons. Mismothering and hypothermia were associated with starvation. Coma-shock resulted from septicaemia, starvation and clostridial infections. Birth stress, omphalitis and trauma were also determined at necropsy. Death due to clinically undetermined reasons resulted from trauma, clostridial infections and WMD *(Table 5)*.

### *Risk Factors*

Evaluation of risk factors revealed that use of hay or straw as bedding, disinfecting pen, shorter interval of cleaning pen, observation during lambing, vaccination of ewes, providing sufficient feeding

***Table 5.*** *Causes of clinically diagnosed cases as determined by necropsy*
***Tablo 5.*** *Klinik vakaların nekropsi sonuçları*

| Clinical diagnosis | Necropsy results | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **S** | **St** | **Cl** | **T** | **WMD** | **BS** | **TB** | **UD** | **O** | **PB** | **Total** |
| Diarrhoea | 9 | - | 3 | 1 | - | - | - | 3 | - | - | **16** |
| Pneumoenteritis | 2 | - | - | - | - | - | - | - | - | - | **2** |
| Pneumonia | 1 | - | - | - | - | - | - | - | - | - | **1** |
| Navel infection | - | - | - | - | - | - | - | - | 6 | - | **6** |
| FAS | 3 | 3 | - | - | 4 | - | 1 | 1 | 2 | - | **14** |
| Mismothering | - | 11 | - | - | - | - | - | - | - | - | **11** |
| Coma-shock | 1 | 1 | 1 | - | - | - | - | - | 1 | - | **4** |
| Hypothermia | - | 2 | - | - | - | - | - | - | - | - | **2** |
| Birth stress | - | 1 | - | - | - | 22 | - | - | - | - | **23** |
| Trauma | - | - | - | 9 | - | - | - | - | - | - | **9** |
| Abdominal mass | - | - | - | - | - | - | 18 | - | - | - | **18** |
| Nervous symptom | - | - | - | - | - | - | - | 3 | - | - | **3** |
| WLS | - | - | - | - | - | - | - | - | - | 26 | **26** |
| Undetermined | - | - | 6 | 9 | 2 | - | - | 9 | - | - | **26** |
| **Total** | **16** | **18** | **10** | **19** | **6** | **22** | **19** | **16** | **9** | **26** | **161** |

**FAS:** Fatigue anorexia syndrome, **WLS:** Weak lamb syndrome, **S:** Septicaemia, **St:** Starvation, **Cl:** Clostridial infection, **T:** Trauma, **WMD:** White muscular disease, **BS:** Birth stress, **TB:** Trichobezoar, **UD:** Undefined, **O:** Omphalitis, **PB:** Premature birth

***Table 6.*** *Management practices affecting morbidity rates*
***Tablo 6.*** *Morbidite oranlarını etkileyen sevk-idare uygulamaları*

| Management Practices | Morbidity (%) rate in farms stating | | Statistics |
|---|---|---|---|
| | Yes | No | |
| Vitamin-minerals | 47.2 (204/432) | 50.1 (196/391) | OR 0.89 (0.6-1.2) $X^2$=0.6, P=0.44 |
| Bedding hay or straw | 42.8 (151/353) | 52.9 (249/470) | OR=0.7 (0.5-0.9) $X^2$=8.0, P=0.004 |
| Cleaning of bedding <7 days | 42.8 (151/353) | 52.9 (249/470) | OR=0.7 (0.5-0.9) $X^2$=8.0, P=0.004 |
| Disinfection <7 days | 42.8 (151/353) | 52.9 (249/470) | OR=0.7 (0.5-0.9) $X^2$=8.0, P=0.004 |
| Observation During Lambing | 42.8 (151/353) | 52.9 (249/470) | OR=0.7 (0.5-0.9) $X^2$=8.0, P=0.004 |
| Vaccination | 42.8 (151/353) | 52.9 (249/470) | OR=0.7 (0.5-0.9) $X^2$=8.0, P=0.004 |
| Adequate feeding | 46.6 (347/744) | 67.1 (53/79) | OR=0.4 (0.25-0.7) $X^2$=11.2, P<0.01 |
| Population density | 47.2 (204/432)a | 50.1 (196/391)b | OR=0.89 (0.6-1.2) $X^2$=0.6, P=0.44 |

**OR:** Odds ratio, **$X^2$:** chi square, **a:** <3.2 lamb/1 $m^2$, **b:** >3.2 lamb/1 $m^2$

were significantly associated with decreased risk. Population density lower than 3.2 lambs/1 $m^2$ and use of vitamin-minerals were also related to decreased risk of morbidity but these were not statistically significant *(Table 6)*.

Neonatal diseases were mainly encountered in the first two week of life and as animal aged the proportion decreased. Neonatal losses were mainly occurred in the first week of life and the proportion decreased gradually as animal aged *(Table 7)*.

Age distribution of the cases revealed that %94.4 of mismothering was in the first week, 66.6% of trauma and 44.4% FAS was in the first week, 68.5% of diarrhoea was in the 1st and 2nd week, 75.8% of navel infections was in the 2nd and 3rd week, 62.1% of pneumonia was in the 4th week and 94.7% of abdominal mass was in the 4th week of life The proportion of diarrhoea, navel infections, FAS, and trauma decreased as age advanced (P<0.005), while the proportion of pneumonia and abdominal mass increased as age advanced (P<0.005) *(Table 7)*.

***Table 7.*** *Age distribution of neonatal cases*
***Tablo 7.*** *Neonatal vakaların yaş dağılımı*

| Age | Diseases | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mb | | Mt | | D | | Mm | | FAS | | Am | | T | | NI | | P | |
| | n=400 (%) | OR | n=172 (%) | OR | n=127 (%) | OR | n=18 (%) | OR | n=27 (%) | OR | n=19 (%) | OR | n=9 (%) | OR | n=33 (%) | OR | n=29 (%) | OR |
| 1 week | 147 (37) | 1.00 | 100 (58) | 1.00 | 42 (33.1) | 1.00 | 17 (94.4) | 1.00 | 12 (44.4) | 1.00 | 0 (0) | NA | 6 (66.6) | 1.00 | 0 (0) | NA | 0 (0) | NA |
| 2nweek | 92 (23) | 0.51 | 19 (11) | 0.09 | 45 (35.4) | 1.10 | 1 (5.6) | 0.00 | 8 (29.6) | 0.53 | 0 (0) | - | 2 (22.2) | 0.14 | 8 (24.2) | - | 6 (20.7) | - |
| 3 week | 60 (15) | 0.30 | 12 (7) | 0.05 | 20 (15.7) | 0.38 | 0 | 0.00 | 4 (14.8) | 0.22 | 1 (5.26) | - | 1 (11.1) | 0.06 | 17 (51.5) | - | 5 (17.2) | - |
| 4 week | 101 (25) | 0.58 | 41 (24) | 0.23 | 20 (15.7) | 0.38 | 0 | 0.00 | 3 (11.1) | 0.15 | 18 (94.7) | - | 0 (0) | 0.00 | 8 (24.2) | - | 18 (62) | - |
| **Statistics** | $X^2$=19.3 P<0.001 | | $X^2$=51.4 P<0.001 | | $X^2$=17.3 P<0.001 | | $X^2$=39.5 P<0.001 | | $X^2$=9.4 P=0.02 | | $X^2$=37.7 P<0.001 | | $X^2$=10.4 P=0.001 | | $X^2$=8.7 P<0.03 | | $X^2$=25.6 P<0.001 | |

**OR:** Odds ratio, **NA:** not applicable, **n:** number of lambs, **$X^2$:** chi square, **Mb:** morbidity, **Mt:** mortality, **D:** diarrhoea, **Mm:** mismothering, **FAS:** fatigue anorexia syndrome, **Am:** abdominal mass, **T:** trauma, **NI:** navel infection, **P:** pneumonia

***Table 8.*** *Association between failure of passive transfer and diseases*
***Tablo 8.*** *Pasif transfer yetmezliği ile hastalıklar arasındaki ilişki*

| Diseases | FPT (+) | | FPT (-) | |
|---|---|---|---|---|
| | n | (%) | n | (%) |
| **Diarrhoea (n=52)** | 10 | 20 | 42 | 80 |
| **FAS (n=15)** | 4 | 26.6 | 11 | 73.4 |
| **Pneumonia (n=6)** | 0 | 0 | 6 | 100 |
| **Total (n=73)** | 14 | 19.2 | 59 | 80.8 |

**FPT:** failure of passive transfer, **n:** number of diseased lambs tested

The percentage of FPT was 15.9% in lambs tested but it was 19.2% in diseased lambs. Cases of diarrhoea and FAS had FPT *(Table 8)*. Fatality of the lambs with FPT was 50% in the first week of neonatal lamb.

## DISCUSSION

This was the first follow up study aimed at disclosing neonatal lamb health in Kars, Turkey.

The descriptive analyses of the data revealed important figures for the first time in the region and Turkey and these figures may be of use for future epidemiological studies in Turkey.

Clinical problems encountered in our study were similar to those reported by other researchers [7-13,15,26,28]. The proportions obtained for morbidity and mortality in this study were comparable, [1,5,9,17,18], lower [8,38] or higher [6,7,11,13,15,16,19,20] than those reported from other parts of the world. The diversity between our findings and the results of other studies may be attributed to the methodological differences as this study comprised only neonatal period [6,20], daily farm visits and veterinary involvement in detecting diseased lambs [1,7,9,19]. Additionally, farm management practices may have also played a role in these differences [5-7,15,19,20] as the management systems reported from developed countries were better than that reported here. Failure of passive transfer is another important factor associated with morbidity and mortality. This was also the case in our study where one in five of diseased lambs had FPT and half of them died [11,24].

Neonatal losses were mainly in the first week of life as reported previously [1,6,7,10,15-18,20,38]. This finding implies that first week of neonatal life is of paramount importance when serious effort is required to prevent losses. Non-infectious causes counted up to 50% of losses which mainly took place in the first two weeks of life in this study as reported earlier by other researchers [1,6,17,18,22,25,26,37]. As for infectious causes, the proportion was around 20% which also confers with some previous results [6,27] but lower [1,28] or higher [39] than others. This discrepancy may once again be attributed to methodological and managemental differences mentioned above.

The proportion of birth stress occurred in this study was similar to that of Cloete et al.[12] but lower than that of Honcock et al.[13]. Proportional mortality rates of birth stress were also similar to some figures [12,13,27,28] but lower than the most of other studies [22,34,37]. Higher rates of birth stress have been attributed to prolonged parturition, twin-triplet births, larger foetus, inadequate feeding, lower body condition score of the dam, higher birth weight of lambs [2,3,12,13,22,34,37]. These were not observed in our study apart from inadequate feeding especially in farm A where this factor was observed the birth stress was also higher.

The proportional mortality rates due to WLS is closer to that of Ameghino et al.[6] but lower than that of Wiener et al.[27]. The marked cause of WLS was premature birth as reported earlier [6,27], but infectious and non-infectious reasons have also been implicated [9,10,16,22,28,35,37]. Factors such as inadequate feeding during pregnancy, poor relationship between lamb and dam associated with WLS [6,16,22,35] as these were also observed in our study. High proportion obtained in this study imposes to carry out a detailed study to disclose underlying causes of WLS in the region.

FAS contributed around one in eight of total deaths. Previous studies [6,10,12,27] described this syndrome under different entities (SME, starvation etc.). Although FAS was clinically defined, the necropsy of these cases revealed that the underlying causes were starvation, WMD, septicaemia, omphalitis. The case fatality of around 50% was similar to previous figures [2,25].

Mortality rate due to starvation was similar to that reported by others [21,26]. Starvation was responsible from 10% of total deaths. This figure confers with few studies [6,28] but lower than many studies from other part of the world [3,8,12,13,22,27,37,39]. Higher rates may be related to the farm management factors as the farms with high deaths had extensive husbandry leading to cold environment and secondary starvation. In this study starvation was mainly due to mismothering as reported by others [6,22] but, to less extent, hypothermia and birth stress were also associated with secondary starvation. Mismothering is attributed to first lambing (primiparous ewes) and inadequate feeding during pregnancy [2,22] as these were the case in only farm A where feeding was inadequate during pregnancy and farm B where many primiparous ewes gave birth. Hypothermia occurred at low level in our study and this was mainly due to intensive husbandry namely lambs were born in the crowded shed among sheep this hindered lambs to be exposed to cold [2,13,27,37,39] but led to other problems such as trauma.

Morbidity and mortality rates of trauma in this study were comparable to those reported earlier [21,28] but the proportional mortality rate was lower [1,6,23,15]. Trauma may be attributed to intensive rearing system, overcrowded housing, no lambing pens, higher population density, mismothering and

unmonitored lambing as in our study farms [2,6,16,22].

The morbidity and mortality of lameness was higher in this study [9,16,26,28,35] but comparable to previous study in the region [29]. The underlying causes were wrong injection by farmers and trauma.

Abdominal mass was another clinical problem in this study. Necropsy of these lambs revealed trichobezoar. Trichobezoar is attributed to insufficient vitamin-mineral supplementation, inadequate feeding, long housing period and intensive rearing system [8,14]. All these factors lead to trichophagia as was the case in our study especially in farms D and C with the high proportion where above factors were markedly present.

WMD contributed to 3.5% of total deaths in this study. Although this result was comparable to the figures reported from other part of the world [26,30] it was higher than the previous report by Ozkan et al.[29] in this region. The difference may be attributed to the methodological differences as farms were daily visited and cases were clinically as well as pathologically diagnosed in this study.

The morbidity of diarrhoea was higher than the earlier studies [9,26,29] but the losses due to scour were comparable to some [27] and lower [8,15,24] than the others. Higher morbidity rate may be related to management differences and to the nature of our study as farms were daily visited by authors which might have resulted in better detection of the cases while other studies either used information provided by farmer [29] or result of diagnostic laboratories [26] and farms were visited weekly or at longer interval [9,15]. Higher morbidity may also be related to farm practices in this study where there was no predefined lambing seasons, no lambing paddocks, unhygienic lamb pen, high population density which may result in accumulation of infectious agents leading to diarrhoea [24,30]. High FPT proportion in diarrhoeic lambs might have also been another reason because one in five of diarrhoeic lambs had FPT and one in third died in first week of life as reported by others [11,24]. This methodological difference might have also contributed to lower mortality rates as duration of our study was short and frequent visit enabled earlier intervention that may have resulted in lower mortality as previously reported for calves [4]. Diarrhoea was common in first two weeks of life as also reported by Andres et al.[24], Ahmad et al.[11] and Sharif et al.[15].

Losses by clostridial infections in this study was comparable to that of Ameghino et al.[6], higher than that of Dohoo et al.[26] but lower than that of Huffman et al.[1]. This difference may be related to study period or different vaccinations programs. The farms in this study did not use clostridial vaccines except farm B. This may have resulted in enterotoxaemia in higher proportion in this study as reported previously [1,6,26].

The morbidity rate of respiratory problems found in this study was lower [9,29] comparable or higher [9,26] than previous studies. However mortality rate was lower than other studies [15,16,20,21,23,25]. The differences may be related to managemental and methodological differences. The lower mortality may be due to study design as it was shorter and visits were made by veterinarians [9]. Another reason may be that respiratory problems are reported mainly after first month of life as this was also the case in this study [6,25]. Visits by veterinarian result in better detection of diseases leading to higher morbidity and in early intervention leading to lower mortality. This might have resulted in lower mortality in this study. Our previous data [40] also shown that lamb had enough maternal antibodies to common viral infections and no bacteria was isolated. This may also explain low mortality rate of respiratory problems.

Navel problem was relatively higher than those reported [9,26] from other parts of the world. This is due to managemental differences as navel treatment was not performed in any of the farms in this study whereas navel treatment soon after birth is a common practice [16,19]. The study design in this work may also resulted higher detection as visits were made by the authors. Mortality due to navel infections was comparable to other [26] but lower than that reported by Yapi et al.[23] and Nobrega et al.[28] but these studies covered longer period (0-11 mount) and number of lambs investigated were quite small. Cases of navel infections (omphalitis and its complications) were commonly diagnosed in 2 and 3 week of life as reported earlier [1,6].

Other clinical problems (nervous symptoms, coma-shock, and congenital deformity) and their rates were similar to previously reported studies [6,9,13,25].

Differences in morbidity and mortality between the farms may be due to different management

practices applied by farms as univariate analyses identified some differences (bedding, cleaning, disinfections, observation of lambing and feeding) but many management practices were similar and number of farms studied was smaller. This made the comparison between farms meaningless but also implied that a detailed analytical epidemiological study should be carried out in this region.

Epidemiological studies on lamb diseases and losses face methodological problems. The first problem of these is study period as determination of periods of perinatal (0-1 day reported by Nash et al.[21], 0-3 day reported by Eales et al.[10], Haughey [22], 0-7 day reported by Cloete et al.[12] or 0-30 day reported by Otesile and Oduye [7], Hancock et al.[13], Nobrega et al.[28] and neonatal (0-28 day or longer reported by Eales et al.[10] and Njau et al.[41] varied from study to study. Another problem is case definition as definition of certain health problems also varied from one study to another. Examples of these are starvation, WLS, stillbirth, birth stress [2,3,22]. The definitions of these clinical entities have differed between the studies. A unique or standard case definition is of importance because wrongly defined or categorised disease entities may not be of help in designing preventive strategies as underlying causative or associated factors may be different for example the aetiology of still birth and birth stress are quite different but some studies [3,7] considered these two diseases as one. Discrepancies in study periods and case definitions lead difficulty in comparing the results of and also drawing conclusion from these studies. Therefore standardising study period and case definitions is important in designing preventive measures.

This study enabled use to disclose on farm events in sheep farms in terms of neonatal health problems. The results revealed that at least one in two lambs contracted disease and around one in five died. These figures along with management faults imply that care should be exercised during neonatal period in order to minimize losses. The results of the study along with future detailed epidemiological studies may be of value in avoiding undesirable effect during neonatal period. This will, in turn, result in increased farm profitability and add value to the economy of region and the country as whole.

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