ARTICLE

# Organ Weights of Normal Broiler Chickens and Those Dying of Sudden Death Syndrome

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## Abstract

**Sudden death syndrome is an economically important condition of fast-growing broiler chickens in which death occurs suddenly with a short, wing-beating convulsion. Gross or histological lesions are not present. Relative weights of internal organs from broilers dead from sudden death syndrome were compared to those of normal broilers to determine differences that might confirm a diagnosis of sudden death syndrome. Relative weights of lung, heart, liver, and intestine from normal broilers were determined at 9, 21, 30 and 42 days of age at various intervals after death. Organ weights stabilized approximately two hours postmortem and relative organ weight declined with age. A diagnosis of sudden death syndrome could not be made on the basis of relative organ weight.**

## Résumé

### Poids des organes de poulets de gril normaux ou atteints du syndrome de mort subite

**Le syndrome de mort subite est une condition qui revêt une importance économique chez les poulets de gril qui croissent rapidement, parce qu'un certain nombre mesurent soudainement après avoir manifesté de brèves convulsions qui s'accompagnent de battements d'ailes. Les poulets qui succombent à cette condition n'affichent aps de lésions macroscopiques ou microscopiques.**

**Les auteurs comparèrent le poids relatif des organes internes de poulets morts du syndrome précité avec celui des mêmes organes de poulets de gril normaux, dans le but de déterminer des différences susceptibles d'aider à confirmer le diagnostic du syndrome précité. Ils déterminèrent à cette fin le poids relatif des poumons, du cœur, du foie et des intestins de poulets de gril âgés de neuf, 21, 30 et 42 jours, à divers intervalles après leur mort. Le poids des organes se stabilisa, environ deux heures après la mort, et leur poids relatif déclina avec l'âge. Il s'avéra impossible de diagnostiquer le syndrome de mort subite, en se basant sur le poids relatif des organes.**

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## Introduction

Sudden death syndrome (SDS) is the primary cause of broiler mortality, representing a loss of 1.5-2.0% of all broilers grown in Canada (1,2,3). The economic importance of SDS has increased as major bacterial and viral poultry diseases have been controlled. Sudden death syndrome affects otherwise healthy, rapidly-growing broilers throughout the growing period, with the peak mortality in Ontario occurring between two and four weeks of age (3). Most of the affected birds (70-80%) are male. Respiratory distress has been reported before affected broilers convulse and die, and over 70% flip over on their backs as a result of terminal movements of legs and wings (3,4).

The specific cause of death in SDS has not yet been determined, although nutritional or metabolic diseases have been suggested (2,4,5,6). At necropsy, the following criteria are suggestive of a diagnosis of SDS (2,3):

1. a normal-appearing broiler found dead (not seen sick), well grown for its age, and in a supine position (significant when present),
2. a full intestinal tract, recently ingested feed in the crop and gizzard, gall bladder small or empty.
3. contracted ventricles and dilated, blood-filled auricles, and
4. lungs and other organs congested, and muscles mottled.

There are no lesions pathognomonic for SDS, and although some pathological studies have reported, changes in the heart and other organs (7), other studies revealed no gross or histological lesions (2,4). Affected broilers are indistinguishable from previously healthy well-grown broilers which die suddenly from other causes (3).

Since the most notable finding in broilers dying of SDS is a full digestive tract and wet, heavy lungs, we measured organ weights at various intervals after death to determine if these gross findings are significant and whether changes occur following death. Normal organ-weight: body-weight ratios for intestines, liver, lung,

and heart were determined for healthy broilers and used as standards for comparison with relative organ weights of chickens that had died from SDS. Significant differences could be used as an aid in diagnosis and/or give insight into the pathogenesis of SDS.

## Materials and Methods

***Control Chickens*** — At 9, 21, 30 and 42 days of age, sixteen male commercial broiler chickens randomly chosen from the normal control group in a feeding trial were killed by cervical dislocation. The carcasses were placed in an open cardboard box in the laboratory at room temperature. At 0 (< 3 minutes), 2, 6 and 12 hours after death, chickens were removed, weighed, and relative weights of internal organs were determined for both lungs together, the heart after removal of the great vessels, gross fat and clotted blood, the liver with gall bladder, and the intestine (duodenum to cloaca inclusive) with contents and pancreas.

***SDS Chickens*** — Broilers diagnosed as having died from SDS were obtained from the normal mortalities of various concurrent feeding and coccidiostat trials and clinical field cases. Ages ranged from 5-49 days. These broilers were dead for fewer than 24 hours since carcasses were gathered daily for necropsy. Autolyzed birds were not examined. Relative organ weights were determined as for the control birds.

***Data*** — Analysis of data was based upon the graphical representation of the relationship of relative organ weight to time after death and to age. Statistical significance was determined using one-way analysis of variance ($p < 0.05$). A Student's t-test was used to compare the slopes and intercepts of the regression lines fitted to be values obtained for relative organ weights of SDS broilers and for normal controls.

## Results

***Time after Death*** — In each age group (9, 21, 30 and 42 days), organ weights were measured immediately and at 2, 6 and 12 hours after death (Table 1).

Changes in relative lung weight in the first two hours following death were significant but inconsistent, i.e. there was a significant loss of relative weight at ages 9 and 21 days yet a considerable relative weight gain at ages 30 and 42 days. There was no appreciable change in weight over the last ten hours except at nine days of age at which time the gain of 46.5% was statistically significant.

Change in relative liver weight between zero and two hours was significant only at nine days of age. There was no significant difference between relative liver weight at 2 and 12 hours.

There was no change in relative heart weight at any time although there was a tendency to lose mass over the first two hours.

There was a significant change ($p < 0.05$) in the relative weight of the intestine over the first two hours during which period there was > 11% gain in all age groups. There was no significant change over the next 10 hours.

***Age*** — Comparison of relative organ weights at 9 and 42 days of age indicated that over this 33 day period the weight of intestine, liver, heart, and lungs decreased 57.5, 35.3, 43.5 and 31.6% respectively (Table 2). These changes were highly significant ($p < 0.001$).

**TABLE 1**
**Relative Weight of Internal Organs of Normal Chickens at 0, 2, 6 and 12 Hours after Death**

| Organ:Age | (d) | % Body Weight at Times after Death (h) 0 | 2 | 6 | 12 | % Change Over 0-2 Hours | % Change Over 2-12 Hours |
|---|---|---|---|---|---|---|---|
| Lung | 9 | 0.975 | 0.784 | 1.075 | 1.149 | −19.6[a] | +46.6[a] |
| | 21 | 0.843 | 0.677 | 0.796 | 0.778 | −19.7[a] | +14.9 |
| | 30 | 0.662 | 0.799 | 0.739 | 0.782 | +17.7[a] | + 0.39 |
| | 42 | 0.665 | 0.858 | 0.797 | 0.825 | +29.0[a] | − 3.8 |
| Liver | 9 | 3.77 | 4.49 | 4.17 | 4.44 | +19.1[a] | − 1.1 |
| | 21 | 3.32 | 3.56 | 3.94 | 3.71 | + 7.2 | + 4.2 |
| | 30 | 3.90 | 3.81 | 3.68 | 3.75 | − 2.3 | − 1.6 |
| | 42 | 2.44 | 2.63 | 3.03 | 2.87 | + 7.8 | + 9.1 |
| Heart | 9 | 0.833 | 0.760 | 0.732 | 0.796 | − 8.8 | + 4.7 |
| | 21 | 0.666 | 0.613 | 0.600 | 0.543 | − 8.0 | −11.4 |
| | 30 | 0.584 | 0.504 | 0.480 | 0.500 | −13.7 | − 0.8 |
| | 42 | 0.473 | 0.485 | 0.515 | 0.432 | + 2.5 | −10.9 |
| Intestine | 9 | 10.85 | 12.13 | 12.17 | 12.30 | +11.8[a] | + 1.4 |
| | 21 | 6.89 | 8.44 | 8.06 | 8.41 | +22.5[a] | − 0.4 |
| | 30 | 6.87 | 7.87 | 8.25 | 7.88 | +14.6[a] | + 0.1 |
| | 42 | 4.73 | 5.47 | 5.80 | 6.21 | +15.6[a] | + 1.4 |

[a]Value represents a significant change ($p < 0.05$) over the time period indicated.

**TABLE 2**
**Change in Relative Weights of Internal Organs with Age**

| Organ | % Body Weight 9 Days | % Body Weight 42 Days | % Change from 9-42 Days |
|---|---|---|---|
| Intestine | 10.85 | 4.73 | −57.5[a] |
| Liver | 3.77 | 2.44 | −35.3[a] |
| Heart | 0.833 | 0.473 | −43.4[a] |
| Lungs | 0.975 | 0.665 | −31.6[a] |

[a]Change is significant at the ($p < 0.001$) level using Student's t-test

***SDS Organ Weights*** — The relative liver weights of broilers dead from SDS showed great variability and were significantly greater ($p < 0.05$) when compared with the liver weights of control birds (Figure 1c). There was no significant difference between SDS and control broilers for the relative weight of lungs, heart, and intestine (Figures 1a, 1b, 1d).

Sudden death syndrome birds displayed a decline in relative organ weight with age that mirrored the physiological decline observed in normal birds.

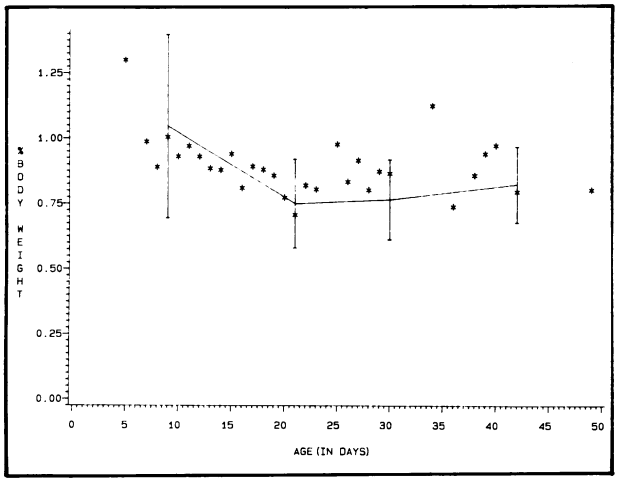


**Figure 1a.** Lung weight as a percentage of body weight for normal and SDS birds vs age. *** SDS — NORMAL with 95% confidence intervals.

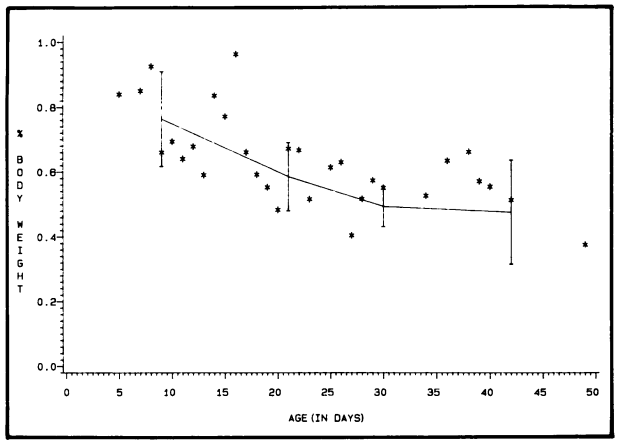


**Figure 1b.** Heart weight as a percentage of body weight for normal and SDS birds vs age. *** SDS — NORMAL with 95% confidence intervals.

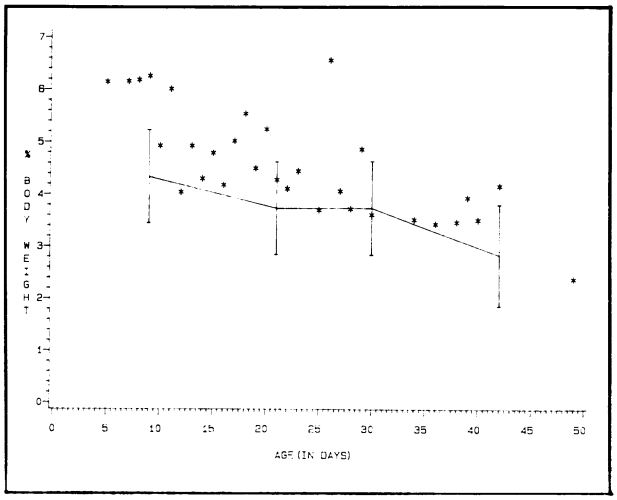


**Figure 1c.** Liver weight as a percentage of body weight for normal and SDS birds vs age. *** SDS — NORMAL with 95% confidence intervals.

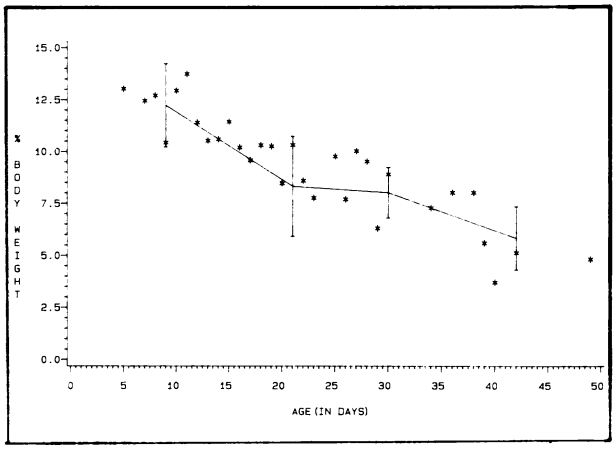


**Figure 1d.** Intestine weight as a percent of body weight for normal and SDS birds vs age. *** SDS — NORMAL with 95% confidence intervals.

## Discussion

***Time after Death*** — Any increase or decrease in relative organ weight during the 12 hours following death was probably due to an osmotic fluid shift coincidental with a nonfunctional Na/K pump. The lung and liver showed the greatest variability in absolute weight which would depend upon the amount of blood present in the organ at death. The inconsistency in the relative lung weights at different ages could be due to physical positioning of the birds following death. The dorsal location of avian lungs would predispose broilers dying on their backs to pulmonary edema as a result of the gravitational settling of fluid and therefore birds placed face down would have lighter absolute lung weights. Liver weight did not change significantly and this may reflect this organ's reduced capacity to sequester extracellular fluid.

The tendency for heart weight to decrease after death could have been due to myocardial contraction (rigor) which continues until adenosine triphosphate (ATP) is depleted. This would force blood and extracellular fluid out of the myocardial mass.

The significant increase in intestinal weight over the first two hours is probably due to osmotic attraction of fluids by the intestinal contents. This fluid shift is complete after two hours.

*Age* — We assumed that organ weights immediately after death would be representative of the true physiological value. During the growth phase, because organ weight as a percent of body weight decreased with age, muscle mass gain must have exceeded organ weight gain. This finding implies a functional organ reserve since a smaller organ can accommodate the increased metabolic load of muscle anabolism and growth.

*SDS Organ Weights* — Liver weights were significantly heavier in birds dead from SDS and although this might be a reflection of the various diets of the field cases, it could be an indication of metabolic disease predisposing to SDS. Since the liver did not show appreciable postmortem weight gain, this would not be a factor in increased liver weight in broilers dead from SDS. Whitehead and Randall (5) reported that broilers dead from SDS had large pale livers with fatty infiltration characteristic of fatty liver and kidney syndrome (FLKS). The authors suggested that subclinical FLKS might predispose to SDS. The full intestine found in SDS broilers in this experiment, and which is one of the diagnostic criteria, appeared to be normal in relation to body weight and is undoubtedly a reflection of the continuing high volume intake of food. Since broilers with FLKS stop eating before signs of disease occur, this observation would suggest that subclinical FLKS is not the cause of fatty infiltration and liver enlargement in broilers dead from SDS. Sudden death syndrome is likely related to some nutritional or metabolic imbalance that results in liver enlargement in affected broilers.

The results of this experiment showed that postmortem changes in weight of lung, liver, intestine, and heart generally stabilize over the first two hours and thereafter remain relatively constant. There is a significant decline in relative organ weight with increasing body weight both in healthy and SDS broilers.

A diagnosis of SDS could not be made on the basis of relative organ weight. The full, dilated intestine can be attributed to continued intake of food. The presence of recently ingested food in the digestive tract and empty gallbladder indicates that the sudden death is not preceded by morbidity. Pulmonary congestion and edema may be due to death in dorsal recumbency or could be an indication that SDS broilers die from left ventricular failure while the right ventricle continues to pump. Sudden death syndrome represents a diagnosis of circumstance, or exclusion, with the large liver, full digestive tract, and lack of specific lesions the most useful criteria.

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