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Neonatal and pediatric care of the puppy and kitten

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Abstract

Although the interval from birth to weaning is brief for dogs and cats, it is a very intensive period of adjustment to the extrauterine environment and preparation for the relatively greater independence of post-weaning. This rapid progression of events is preceded by critical developmental transitions, including organogenesis and parturition, and it is characterized by postparturient transitions that include the 3–4 d neonatal period, the 21–28 maturation, and weaning itself. The purpose of this discussion is to characterize the primary events of these five transitional zones and to describe practical methods for evaluating progression through each transition, for establishing differential diagnoses, and for supportive actions and responses.

Keywords: Pediatrics; Neonatal; Perinatal; Dog; Cat

1. Introduction

A successfully weaned puppy or kitten has made a series of critical transitions at specific times during the developmental continuum [1]. The transitions at organogenesis, parturition, the 3–4 d neonatal period, the 21–28 maturation, and weaning, represent high-risk zones for abnormal developmental events and extrinsic insults. Some of these events affect short-term fetal survival and can result in termination of pregnancy or neonatal losses; others become evident much later, either during or following adolescence. The purpose of this discussion is to consider pediatric management in clinical settings, with an emphasis on preventing problems from the neonatal period through weaning. The most common problems that clinicians are likely to encounter will be the primary focus.

2. The neonatal period

The mortality pattern in a group of non-surviving puppies, from a large facility that was managed carefully, is shown (Table 1). These data provide a general guideline for expected mortality in young dogs, which overall should represent no more than 12–15% of full-term births by the time of weaning. However, losses over short intervals may be greater or lesser, depending on the influence of environmental factors. Stillbirths should be <30% of full-term puppies that do not survive to weaning.

Fox described a final common pathway of cardiopulmonary collapse in non-surviving neonates [2]. A high percentage of neonatal puppy and kitten mortalities have combinations of pulmonary congestion, edema, hemorrhage, and atalectasis, although the pulmonary histology of surviving age-matched siblings usually is unknown. Several recognizable factors can influence transition to this final common death trajectory.

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Table 1
Summary of causes of mortality in puppies ($n = 421$)

Age	Number (%)
Parturition (stillbirth)	126 (29.9)
Days 0–3 (live birth)	209 (49.6)
Days 4–28	71 (16.9)
Days 29–42	5 (1.2)
Days 42–45 (postwean)	10 (2.4)

2.1. Weight

Birth weight is an important survival determinant in most mammalian species. In a study of 477 kittens, 60% of those with low birth weight did not survive, whereas 68% of kittens with normal birth weight survived to weaning [4]. Low birth weight is accompanied by immature physiological processes that can lead to extrauterine adaptive failure, often associated with inadequate production or release of lung surfactant [3]. Important influences on canine and feline birth weight include parental age and state of health, placental sufficiency, litter size, gestational nutrition (at extremes), infections (including parasites), and environment (sanitation, stress). In a study of neonatal English Pointers, post-whelping weight gain, or loss of <10% of birth weight during the first 12 h post-whelpings, were both accompanied by lower risk for mortality [5]. Therefore, very early post-whelping weight changes also impacted survivability.

Simple and inexpensive means are available to monitor and support neonates with low birth weight or risk for weight loss: (a) weigh high-risk neonates at birth, between 12 and 24 h postpartum, and then daily until consistent weight gain is observed. Continue weighing one to two times weekly through weaning, and monitor muscle tone, activity, and response to handling on a daily basis; (b) weigh high-risk neonates before and after suckling to document intake; (c) provide colostrum intake via suckling, milking the dam and hand feeding, or administering dam serum (depending on circumstances); (d) intervene with feeding support when weight declines or gain is inadequate; and (e) maintain stable temperature and hydration.

2.2. Colostrum

Colostrum ingestion increased serum immunoglobulin concentrations in neonatal kittens, documenting successful transfer of passive immunity and suggesting electrophoresis as one method to assess colostrum status [6]. Colostrum ingestion in neonatal puppies dramatically increased serum alkaline phosphatase (30 times adult serum concentrations) and gamma glutamyl transferase (100 times adult serum concentrations) [7]. Serum alkaline phosphatase and gamma glutamyl transferase concentrations might be more readily available (and less expensive) than electrophoresis, if documenting colostrum ingestion is necessary. It is noteworthy that bone growth also elevates serum alkaline phosphatase, but growth-related serum concentrations of alkaline phosphatase seldom exceed four times average adult concentrations.

2.3. Hypoxia and acidosis

Hypoxic puppies may not show a hyperventilation stage, thus complicating recognition, although the expected late respiratory depression nonetheless follows predictably. A further complication is that combined respiratory and metabolic acidosis is a normal event following canine and feline birth. In the normal birth event, spontaneous recovery of acid–base stability occurs over 2–3 h. Clinical status and responsiveness, temperature, respiratory and heart rates, and character of respiration, seem to be adequate measures by which to judge interventional needs [8].

Resuscitation procedures that can help prevent deterioration of acid–base stability include vigorous attempts to induce and support breathing by clearing oronasal passages and by physical stimulation, such as external rubbing and gentle intermittent stretching. Sublingual injection of pharmacological respiratory stimulants and sheltering in an incubator (if available) are appropriate interventions. Temporary introduction to a 30–40% oxygen environment may reduce distress if respiratory function continues to be inadequate.

Hypoxia at birth also can predispose to fatal necrotizing enterocolitis. In one study, however, colostrum-deprived puppies were susceptible, whereas colostrum-fed puppies did not develop enterocolitis, underscoring the importance of avoiding colostrum-deprivation [9]. Bradycardia and hypotension frequently accompany hypoxia, perhaps at least partly as evolved defense mechanisms. However, neonates that exhibit bradycardia and signs of hypoperfusion need to be monitored, and usually require careful fluid and thermal support. It is critical that colostrum intake be provided to these patients [8].

2.4. Temperature

Rectal temperature normally declines just after birth, probably as an adaptation to protect from hypoxia and acidosis by reducing metabolic demand [10,11].

Post-recovery from initial decline, normal rectal temperature is 35.0–37.2 °C (95–99 °F), increasing to 36.1–37.8 °C (97–100 °F) by 14 d. Adult rectal temperature and auto regulation occur by 28 d [12]. Hypothermia suppresses gut motility, especially below 34.4 °C (94 °F) rectal temperature, and also suppresses appetite, possibly as an adaptive response to reduce risk for aspiration.

Rapid warming increases metabolic demand, with risk of exceeding the delivery capacity of circulatory and pulmonary function; this can cause loss of cardiovascular integrity, secondary hypoxia, cerebral changes, and sepsis. Slow warming, over 1–3 h, followed by parenteral fluid support, are the primary therapeutic steps. Oral alimentation is established or re-established after normothermia is achieved [3]. Neonates that have been given supportive warming should be monitored frequently during lactation for reoccurrence of hypothermia. Voluntary suckling behavior and ambient temperature also should be monitored carefully.

2.5. Hydration

Many intrinsic and extrinsic factors can lead to fluid deficit in neonatal dogs and cats. High body surface:-volume ratio, more permeable skin, high water weight (80%), and immature renal water conservation are predisposing factors. Water deficits most frequently are caused by prematurity; diarrhea or pneumonia; excessive ambient temperature; and reduced intake secondary to inadequate suckling or poor lactation. Conversely, overhydration can result if rehydration is too aggressive. The most serious complications of overhydration include cardiovascular overload, pulmonary edema, and intracranial hemorrhage, any of which can lead rapidly to death [13].

Depending on synergistic effects of ambient temperature and rate of water loss, dehydrated neonates may require from 60 to 180 mL/kg/d for fluid support. Oral rehydration is preferred if gut function is normal and the neonate is not hypothermic. Since compromised neonates have increased susceptibility to bacterial infections, parenteral routes for rehydration need to be used with scrupulous sterile technique. Subcutaneous administration is the parenteral route used most frequently. Intravenous administration is more difficult and stress producing, but frequently can be used to administer small boluses, e.g. 10 or 50% dextrose if hypoglycemia is suspected. Intraperitoneal injections often are given to rodents, and represent an access route in the presence of stable temperature and cardiovascular function. In the author's opinion, intraosseus administration to canine and feline neonates is difficult to recommend, due to the danger of serious bone damage. In all cases, administration of warmed fluid is necessary.

Other actions that should accompany recognition and correction of dehydration in neonates include: (1) continued monitoring for reoccurrence after resolution (monitoring is done most easily by assessing short-term weight changes and the condition of oral membranes and skin); (2) monitoring the dam's milk production and maternal behaviors; and (3) monitoring ambient conditions.

2.6. Hypoglycemia

The natural inclination to feed neonates as soon as possible is understandable, since a group of periparturient complications can predispose to hypoglycemia. These include placental insufficiency; prematurity or hypoxia; hypogalactia or agalactia; poor ambient conditions; and sepsis [14]. However two interesting studies provide additional clarification for evaluating potential glycemic status. In one study, healthy unfed (3–9 h postpartum) neonates had reduced blood glucose only if the dam was fasted for 72 h prior to birth [15]. In the other study, healthy fasted neonates were normoglycemic at 24 h, but had lower fatty acid production that indicated substrate depletion [16]. The results of these studies were compatible with observations that empirical therapy with oral or intravenous glucose frequently does not lead to a clinical response in neonates. Two possible underlying factors that influence this outcome are that some individuals may be normoglycemic or only slightly hypoglycemic, or the state of cardiovascular collapse may preclude response, regardless of glycemic status (the latter should be obvious) [17].

2.7. Supporting the neonate

Dramatic systemic biochemical changes occur when failing neonates approach a moribund state (Table 2); hypoglycemia, hypovolvemia, hypoalbuminemia, altered energy pathways, arrested growth, and acid–base dysregulation all are suggested. This constellation of observations is consistent with systemic multiorgan failure.

The ideal circumstance always is prevention. A number of simple actions can help minimize stresses that contribute substantially to neonatal failure:

(a) Crowding is the most common error in group environments. Consequences of noise, poor sanita-

Table 2
Clinical chemistry in moribund and normal puppies during Week 1

End point	Normal, Day 1 ($n = 6$)	Normal, Day 4 ($n = 7$)	Normal, Day 7 ($n = 9$)	Moribund, Days 1–7 ($n = 24$)
Hematocrit (%)	36	41	37	56
Glucose (mg/dL)	106	114	129	33
Urea nitrogen (mg/dL)	33	27	24	76
Creatinine (mg/dL)	0.6	0.4	0.4	0.9
Uric acid (mg/dL)	2.6	3.0	3.7	4.1
Total bilirubin (mg/dL)	1.3	0.8	1.2	3.9
Lactate dehydrogenase (U/L)	364	370	590	514
Aspartate aminotransferase (U/L)	90	41	65	130
Alanine aminotransferase (U/L)	38	22	22	96
Total protein (g/dL)	4.0	4.3	4.3	4.3
Albumin (g/dL)	2.3	2.3	2.3	2.3
Cholesterol (mg/dL)	112	219	299	180
Triglycerides (mg/dL)	63	151	218	60
Alkaline phosphatase (U/L)	1069	390	242	342
Calcium (mg/dL)	11.5	12.1	11.8	9.0
Phosphorus (mg/dL)	8.4	8.2	10.3	13.5
Magnesium (mg/dL)	2.7	2.5	1.9	3.5[a]
Potassium (meq/L)	5.8	5.7	6.1	7.5
Sodium (meq/L)	147	146	148	149
Chloride (mmol/L)	104	108	111	109

[a] $n = 12$.

tion, distraction of dams, and facilitated transmission of infectious agents are common underlying influences on various neonatal problems. In home environments, excessive noise and activity in the maternity area should be avoided.

(b) Colostrum intake is critical, principally because of passive antibody transfer. Neonates should be encouraged to suckle frequently during the first 72 h after birth. If necessary, suckling may be supported by placing the mouth of the neonate on the nipple while gently squeezing a small amount of milk onto the neonate's tongue, repeated several times each 24 h.

(c) Environmental guidelines for ambient temperature for orphaned puppies include: 29–32 °C (85–90 °F) through Day 7; 27 °C (80 °F) from Days 8 through 28; 21–24 °C (70–75 °F) from Days 29 through 35; and 21 °C (70 °F) thereafter. Ambient temperature should be monitored via thermometer and drafts must be prevented. Excessive ambient heat is recognized by changes in litter positioning (separated vs normal huddling), character of respiration (hyperthermia results in hyperventilation and open-mouthed breathing), elevated rectal and skin temperature, and distress vocalizations that express discomfort.

(d) Very attentive dams may be reluctant to leave a litter to feed themselves. Food and water should be in easy proximity. Adding 50% warm water by weight increases aroma and palatability, but must be replaced at regular intervals. The maternity environment should be warm, dry, quiet, and draft-free. Caretakers should be familiar to the dam, and should frequently monitor the dam's lactation performance and interest in maternal care.

(e) Frequent weight measurement is an inexpensive and very valuable measure of progress or early recognition of problems. Short-term weight fluctuations often relate to fluid balance. The goal is consistent daily weight gain that reflects positive nitrogen balance.

(f) The primary neonatal activities are eating and sleeping. Outward clinical appearance can reflect distress, but usually does not suggest cause [18]. The litter should be monitored daily for decreased activity and muscle tone, which often precede onset of more serious deterioration. Sleep deprivation of neonates must be avoided.

2.8. Feeding support

Providing support for low birth weight neonates is challenging. Assisted suckling or feeding in small amounts at 2–3-h intervals reduces risk for volume overload, abdominal discomfort, diarrhea, and aspiration. Colostrum deprivation following birth hypoxia greatly increases risk for physiological complications such as necrotizing enteric disease and septicemia, especially in the subject with low birth weight. Recognizing this possibility early, and providing colostrum intake, can be critical for survival [19].

The energy requirement for neonates approximates 20–26 kcal/100 g body weight daily (given over multiple feedings). Most commercial milk replacers deliver approximately 1.0 kcal/mL; maximum comfortable stomach capacity approximates 4 mL/100 g body weight. Thus, readily available data permit estimation of required daily intake and feeding frequency.

2.9. *Example*

A 0.9 lb puppy (409 g) requires approximately 4.09×23 kcal = 94.1 kcal/d. If a formula contains approximately 1 kcal/mL, a daily volume of 94 mL of milk replacer should meet ongoing nutritional needs. Maximum comfortable stomach capacity for a 0.9 lb puppy is 4 mL/100 g $\times$ 4.09 = 16.4 mL; to deliver a total intake of 94 mL/d requires six equally spaced feedings of ~16 mL each (Table 3).

Many clinicians prefer to initiate supportive feeding with meals approximating 50% of calculated volumes, to avoid volume-related aspiration accidents, and to adjust gut flora to the regimen. In some instances, especially with more precarious subjects, intake may need to remain lower for several days, with daily amounts that do not exceed 10% of body weight. Smaller oral amounts can be given more frequently, and ongoing fluid losses from diarrhea or ambient conditions can be addressed by adding subcutaneous isotonic fluid to the treatment protocol [20].

Milk replacers, of necessity, represent the average of changing milk nutrition through lactation [21]. Puppies that are fed milk replacers should not be expected to maintain growth rates in parallel to those fed with dam's

Table 3
Nutritional support for young puppies and kittens

Equipment	
Syringe	Plastic, 10–50 mL
Tubing	7-French rubber catheter (avoid small catheters, as they may loop into the esophagus and lead to aspiration)
Adhesive tape	To mark the depth of the tube for insertion into the stomach
Disinfectant	To flush the tube and syringe after each feeding (rinse with copius amounts of water after disinfection)

Formula
- Bitch milk, acquired by milking a lactating bitch
- Commercial bitch milk replacer
- Emergency home-formulated replacer (intended for short-term support only; not intended for complete rearing):
  1 cup (250 mL) cow's milk
  3 egg yolks
  1 drop high-quality oral multiple vitamin solution
  1 tablespoon (15 mL) corn oil
  Small pinch of salt
  Directions: Blend uniformly and warm to 35–38 °C (95–100 °F; ~human body temperature). Refrigerate between uses.

Administration

Mark tube: The feeding tube should extend into the puppy's stomach, but not far enough to cause risk of looping and return to the esophagus. The length that is needed can be measured along the outside of the puppy's body. A piece of tape can be placed to mark the correct distance for insertion to just behind the last rib, which will place the tube into the puppy's stomach.

Replace flexible feeding tubes at intervals of $\leq$1 d (the tubes become less rigid and more liable to loop). Feeding tubes also need to be disinfected and then rinsed thoroughly between feedings in the same day.

Preparation: For puppies <2 wk old, the formula should be warmed to (age-appropriate) body temperature, because independent thermoregulation is still poorly developed. Prior to placing the tube, it should be filled with milk or milk replacer to eliminate administration of air.

Placing the feeding tube and administering the feeding: The feeding tube is carefully placed to the depth of the marker tape. The puppy is not strongly or forcibly restrained. Excessive restraint can provoke struggling and increase risk for aspiration or other feeding accidents. Administering the feeding also is done with minimal restraint. Some puppies "prefer" to crawl around on a flat surface while being fed, with only sufficient restraint to keep the head elevated and maintain the tube placement. This is safe and acceptable.

Elimination

Unless the dam is present and can give supportive care to hand-rearing efforts, it is necessary to stimulate the external anal and urinary orifices of puppies after each feeding, to effect defecation and urination. This is done by gentle massage of the orifices with cotton or a soft cloth. This process must continue until puppies begin to urinate and defecate voluntarily, which will occur by Days 14–21, depending on the condition and rate of maturation of the puppies.

milk. It is unusual for these differences in growth rate to be consequential. Young dogs and cats that are being support-fed should be monitored carefully for nasal discharge of milk, regurgitation, bloating, abdominal discomfort, and diarrhea; these signs can indicate overload, undesirable changes in gut microbiota, or impending medical complications such as sepsis. The author recommends caution with oral drug use when digestive upsets accompany supportive feeding, because absorption and effects of drugs may be erratic.

Proximate analysis of dams' milk varies widely among species. For example, casein and whey protein contents are 0.4 and 0.6% (human); 2.5 and 0.4% (goat); and 5.8 and 2.1% (dog) [22]. Even from cursory examination of a single nutrient, it is readily apparent that the natural milk of these species cannot supply the basic nutritional needs of the others. Furthermore, the lengths, anatomical structures, and physiology of their gastrointestinal tracts differ, indicating that absorptive, metabolic, and excretory processes also differ. Humans are monogastric omnivores, goats are ruminants, and dogs are monogastric carnivores [23]. These differences necessarily imply phylogenetically derived variances in eating habits and assimilation. Complete and balanced nutrition cannot be supplied by cross-species substitutions of milk.

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3. The 21–28 d maturation

The 21–28 d maturation is a brief but intense period of neurological and behavioral maturation that leads to high-risk weanlings if it does not progress normally. Uncoordinated walking begins by 18–21 d, with coordinated walking by Day 28, coincident with normotonia and early environmental exploration.

Neonatal reflexes for rooting and suckling become extinct between Days 25 and 28, but these reflexes may persist in orphans and immature subjects. Anogenital reflexes also should disappear just prior to, or during, this week. Poikilothermy gives way to autonomic thermoregulation by the end of the fourth week.

Sound orientation occurs at approximately Day 21, and visual depth perception develops by approximately Day 28 [24]. However, impaired hearing can be difficult to evaluate in individuals that are kept with litters, since most hearing-impaired puppies readily follow sibling behaviors. Deafness frequently is recognized only after a puppy is placed as a pet, or begins a training program. Similarly, visual deficits, especially partial deficits, also can be difficult to evaluate while puppies remain in a pre-weaning grouped environment.

Factors that predispose to inadequate 21–28 d maturation include low birth weight or excessively slow rate of growth, inadequate colostrum intake, effects of parturient and neonatal insults such as hypoxia, and unrecognized concurrent diseases [19]. Within each of these categories, multiple underlying etiologies are possible, but the common outcome is delayed "psycho-social" maturation and lack of preparedness for the independence of weaning. Frequently, it is these subjects that experience post-weaning wasting (described below).

By Day 28, puppies and kittens should have begun initial stages of transition to voluntary consumption of moistened solid foods; clinical evaluation is warranted if there is any delay of this maturational sequence. The most important preventive measure is frequent weight measurement during lactation, and early intervention with feeding support and hydration (Table 4).

The author prefers to initiate feeding with a warm gruel, between Days 21 and 28, depending on individual sizes and maturity of the litter. Adding 50% warm water by weight and mixing in a blender is a simple preparation method; additional water may be added if needed. The food should be introduced twice or thrice daily, prior to a suckling period. The product used should be a high-quality puppy or kitten food that will be fed after weaning. Pre-weaning feeding periods should be monitored until self-feeding is safely established.

The "traditional" practice of supplementing with vitamins, minerals, or other single additives is highly

Table 4
Actions to support normal 21–28-d transition

- Daily monitoring by trained observers: alertness, weight, food intake, sleep
- Support faltering weight gain with early gruel feeding
- With even mild depression, monitor blood glucose, neurological signs, hydration, temperature
- Shelter from opportunities to acquire infections; maintain spatial isolation
- Assess environmental physical safeguards
- Evaluate projected weaning dates and plan needed post-weaning support
- Evaluate the post-weaning environment based on anticipated needs of the individual
- Necropsy non-surviving subjects

inadvisable. These unnecessary practices can lead to induced nutritional disorders brought about by excesses and interactions [1]. Nutritionally complete and balanced foods are of paramount importance to proper development and maturation. The physical form of the food offered is extremely important, as individuals and litters vary in their rates of maturation and in eruption of dentition. All diets fed during growth and reproduction should be validated by actual feeding studies.

Vaccination schedules and parasite control should be introduced at the discretion of the clinician. In population-dense environments, the author has used pyrantel at 14-d intervals, beginning at 14 d.

4. Weaning

The two important transitions of weaning are permanent shift from dam's milk and physical separation from the dam (and perhaps siblings) [1,25]. Important influences on success of weaning include: (a) birth events, particularly weight, oxygenation, and hydration, all of which affect capacity for timely maturation; (b) colostrum intake and resolution of any birth-associated complications; (c) early weight gain; and (d) success of the 21–28 d maturation. Post-weaning transitions, coupled with separation anxiety that occurs in many immature weanlings, may compound other problems and lead to serious morbidity [1].

Weaning should be supported nutritionally by continuous feeding of the same high quality food, from first introduction. This practice helps reduce the potential for digestive disturbance or diet rejection that can result from sequential food changes or lower quality products. The author prefers to avoid specialized 'weaning diets' because they represent additional challenges to adjustment of important gut microbiota.

Feeding should be done in a quiet area, with careful attention to avoiding learned aversions. Manufacturers' feeding recommendations are guidelines only; individual requirements normally vary by up to 20% above or below a "group" mean. Growing puppies must be fed as individuals and monitored frequently (Table 5). Diet change should not be the first response to negative observations. Rather, the evaluation process should include individual, group, and environment, and should be pursued in an orderly process, as for any clinical presentation.

Table 5
Steps to support weaning in puppies

- Anticipate weaning needs: monitor pre-weaning transitions; address deficits early
- Monitor food intake daily; avoid multiple diet transitions
- Monitor weight and hydration frequently; provide continuous fresh water
- Monitor activity and interactions with dam and siblings
- Observe dental eruption
- Monitor fecal quality and gastrointestinal signs, respiratory signs
- Monitor for depression and separation anxiety
- Minimize environmental noise, dampness, drafts
- Avoid temperature extremes and rapid changes, provide adequate ambient warmth
- Maintain relative humidity 40–70%
- Provide gentle handling and socialization, adequate sleep time
- Avoid feeding coincident with stressful events to minimize learned aversions
- Avoid pharmacological appetite stimulation if possible
- Consider stabilizing gut microflora with probiotics[a]
- Feed in a warm and quiet environment with minimal competition among siblings
- Add warm water to food, 50% by weight at 26–39 °C (78–103 °F)
- Avoid milk-based foods in the presence of diarrhea

[a] Forti-Flora®, Nestle Purina Co., St. Louis MO, USA.

5. Wasting

Unresolved maladjustment between birth and post-weaning can terminate in a non-specific syndrome called wasting (fading). Wasting is characterized by progressive clinical decline associated with anorexia, growth failure, depression, dehydration, and increasingly poor response to environmental stimuli. Confirmed or suspected causes of wasting include: inborn metabolic errors; immunological traits; bacterial, viral, and parasitic infections; congenital or acquired organ dysfunction; immature cardiopulmonary or other metabolic functions [3]. Based on these observations, wasting is not a single type of event, but can have numerous etiologies [26]. The predisposing event(s) often begin during early- to mid-lactation. For example, body weight data from a group of kittens that developed wasting after weaning are shown (Table 6). Birth weight either was low initially, or early daily weight gain was marginal to subnormal. Based on these data, most of this group was predisposed to develop wasting well before weaning, and well before clinical presentation.

Lactation quality and quantity are extrinsic (to the suckling infant) influences that can be affected by any intrinsic (to the dam) stress, especially disorders that lead to reduced food or fluid intake, fluid loss, and electrolyte or acid–base imbalance. Other common extrinsic problems that predispose offspring to wasting include excessive handling of the neonate or the anxious weanling (causing inadequate sleep); inexperienced or behaviorally maladjusted dam; inattention as a dam-related culling process; exposure to infectious agents;

Table 6
Weight patterns of 15 pre-wasting kittens

Age (d)	Expected (g)	Mean (range) actual (g)	Average daily gain (g)
Birth	100	84 (68–115)	
7	170	147 (134–182)	9.0
14	240	199 (170–242)	7.4
21	310	250 (174–354)	7.3
28	380	288 (203–448)	5.4
35	450	352 (278–540)	9.1
42	520	436 (360–648)	12.0

inattentive caretakers; and overcrowded or distracting environments.

Affected individuals often present well into the wasting process, with clinical signs that reflect secondary infections, making recognition of pre-existing problems quite difficult. Young dogs and cats with wasting, however, frequently have reduced serum alkaline phosphatase and phosphorus concentrations that indicate arrested growth, and increased cholesterol and triglyceride concentrations that indicate activity of alternate pathways for energy metabolism.

Management of wasting tends to be primarily supportive, in addition to identifying and treating obvious problems at presentation. A summary of approaches to managing wasting is shown (Table 7).

Table 7
Supportive therapy for wasting syndromes

- Maintain an index of suspicion for undersized, underweight weanlings
- Obtain as much recent and more distant history as possible
- Feed moist (50% or more added water by weight) products warmed to 25–39 °C (78–103 °F) in a wide, shallow bowl
- Feed in a warm, quiet, dry place; weigh before and after feeding to gauge intake
- Attempt early oral alimentation, but do not force
- Observe for food- or food-related aversions
- Maintain adequate hydration and monitor for hypothermia (depresses appetite)
- Taste preferences are not defined well until after the 3rd month of life, but do not carry novelty to extreme
- Avoid prolonged exclusive use of milk replacers to prevent uncorrectable habituation
- Monitor tooth eruption (affects voluntary consumption)
- Puddings and yogurt can add appeal and moisture at low pH, for top-dressing (feline)
- Fish odors often are attractive (feline)
- Top-dress food with small amounts of warmed meat-flavored baby foods
- Weigh provided foods before and after feeding to gauge intake
- Do not leave moist foods to access for prolonged periods
- Weigh daily during treatment

6. Adolescence

The idea of "complete and balanced nutrition" based on life stage is not new in the pet food industry. However, a series of advances in nutrition science have redirected the understanding of this term. Even among sibling dogs, for example, individual energy requirements may vary at all life stages by as much as 20% above or below a "group" mean (Kealy and Lawler, unpublished data). Another complication is that ambient temperature has substantial influence on daily energy requirement (energy requirement is substantially higher during colder seasons). The necessity for size-specific supply of certain nutrients also is understood differently today. For example, the calcium requirement of the growing large- or giant-breed puppy falls within a relatively narrow range, with obvious growth and health deficits occurring on either side of the requirement. Thus, growth, health, and nutrition must be maintained in careful balance, based on the needs of the growing dog as an individual.

Diet restriction (DR; energy restriction) has been recognized for approximately 75 y an important life-extending intervention in many species, ranging from simple single-celled organisms and invertebrates to complex vertebrates that have included numerous rodent species and strains, and several species of primates [27]. To evaluate the effect of DR in dogs, a study was initiated in early 1987 and was continued for the lifetimes of all of the dogs. From a brief clinical perspective, the lifetime data demonstrated that diseases that led to death were similar between the two feeding groups; principally, the time of death differed. This observation aligns with similar research with other species [28–30].

The robust DR intervention extends longevity across great evolutionary distances. It is likely that basic conserved genetic mechanisms, such as stress response capacity and its interactions with insulin–glucose and oxidative metabolism, are involved in the DR response. It is unlikely that any single response explains the longevity effect, and equally unlikely that intervention with any single substance will produce the same longevity effect. Lifetime commitment to managing energy intake is associated with a longer and better quality life from puppy hood through adolescence, during adulthood, and continuing into late life. It is important to note, however, that the natural history and physiology of the domestic cat differs considerably from that of the dog. In addition, recent observations suggest that the late-life implications of these differences may need to be evaluated in a different context than DR [31].

7. Conclusions

Clinicians, breeders, caretakers, and pet owners can facilitate successful postweaning transition of puppies and kittens to permanent homes or other environments, often using relatively simple means. In essence, this process involves: (a) understanding the primary events that occur at each of the critical developmental transition zones; (b) carefully assessing available historical information; (c) performing physical evaluation and expanding the information base using an orderly process of thought and inquiry; (d) intervening early to support resolution of specific problems; and (e) planning future preventive strategies.

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