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# Passive transfer of immunity in horses

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**Summary**

Failure of passive immune transfer (FPT) through colostrum absorption is still fairly frequent and responsible for a large proportion of cases of neonatal mortality in newborn foals. The most frequent causes of FPT are: low quality maternal colostrum (IgG < 40 g/l is observed in about 30% of all foaling mares) and/or a delay in ingestion (> 12 hours after birth). Colostrum quality can be measured reliably and rapidly under field conditions using a modified sugar refractometer (Colotest®). If maternal IgG content is too low, good quality colostrum can be given (> 1 litre) to the foal within 9–12 hours post -partum to prevent FTP. Ingestion of low quality colostrum, an artificial milk or an electrolyte solution by the foal before ingestion of good quality colostrum does not seem to prevent a correct level of protection. To date, there is no satisfactory colostrum substitute for complete colostrum replacement available on the market and the use of banked frozen colostrum is recommended. Recent research in our laboratory, however, shows that a freeze-dried extract of equine colostral IgG can provide satisfactory immune protection when used as a complete substitute for colostrum. Furthermore, the induction of lactation in selected barren mares may offer an alternative way to produce colostrum when needed.

**Keywords:** colostrum, horse, foal, passive immunity, disease

**Passive Immunisierung bei Pferden**

Das Versagen der passiven Immunisierung durch Kolostralmilch (FPT, failure of passive immune transfer) tritt noch immer häufig auf und ist in hohem Maße die Todesursache neugeborener Fohlen. Die häufigsten Gründe für FPT sind schlechte Qualität des Kolostrums des Muttertieres (IgG < 40g/l, tritt bei 30% der Stuten auf) und/oder eine verzögerte Milchaufnahme durch das Fohlens (> 12 Std. nach der Geburt). Die Qualität des Kolostrums kann unter Praxisbedingungen schnell und sicher durch den Einsatz eines *modifizierten Zuckerrefraktometers* (Colotest®) bestimmt werden. Ist der IgG Gehalt zu niedrig, kann zwischen 9–12 Stunden postpartum ein qualitativ hochwertiges Kolostrum (mindestens 1 Liter) zugefüttert werden, um FPT zu vermeiden. Die Aufnahme von minderwertigem Kolostrum, Milchersatzstoff oder elektrolytischer Lösung vor diesem Zeitpunkt scheint keine ausreichende Immunisierung gewährleisten zu können.
Bis heute ist kein zufriedenstellender und vollständiger Ersatz für das Kolostrum auf dem Markt und die Einrichtung einer Gefrierbank für Kolostrum wird empfohlen.
Jüngste Forschungen in unserem Labor haben jedoch ergeben, dass ein gefriergetrockneter Extrakt von equinem kolostralem IgG bei Einsatz als vollständiger Ersatz für Kolostralmilch für zufriedenstellende Immunisierung sorgen kann. Des weiteren könnte die Einleitung der Laktation bei ausgesuchten güsten Stuten eine Möglichkeit zur Produktion des benötigten Kolostrums sein.

**Schlüsselwörter:** Kolostralmilch, Pferd, Fohlen, passive Immunisierung, Krankheit

## Introduction

Neonatal mortality is high in the equine species: in France, 12% of the foals die between birth and 3 months of age, with more than half suffering from an infectious problem *(Chavatte and Collobert, 1994)*. Foals are born without any immune protection as immunoglobulins do not cross the equine placenta *(Jeffcott, 1974)*. The immune protection of the foal during the first 4–8 weeks after birth is normally conferred by the ingestion of maternal colostrum at birth.

## Colostrum and passive transfer of immunity

Maternal colostrum is produced for the first 12 hours post-partum with a total of 103 ± 71 g IgG secreted on average per lactation per mare. The highest concentrations are found in the first litre produced. Mean colostrum production is 2.5 ± 1.3 litres (N=27) for saddlebred mares (figure 1) *(Clément et al., 2000)*. If the foal sucks normally within 2 hours after birth, serum IgG become detectable by 6 hours and with a peak at 12–18 hours *(Massey et al., 1991)* (figure 1). In general, plasma IgG levels are higher than 8 g/l by 18–24 hours. Their half-life is 26 days *(Lavoie et al., 1989)*. Meanwhile, the foal's immune system becomes active and becomes similar to that of the adult by 4 months of age. The most critical period in terms of low plasma IgG concentrations is between 1 and 2 months of age.

## Failure of Passive transfer of Immunity (FTP)

Complete FTP occurs when plasma IgG are < 2–4 g/l at 12 hours after birth. Partial FTP is diagnosed when IgG levels are below 8 g/l. *(Koterba, 1990; LeBlanc et al., 1986; Leblanc et al., 1990; Stoneham et al., 1991; Vivrette et al., 1998)*. Other substances present in colostrum also contribute to the foal's protection (IgA, trypsin inhibitors, lactoferrin, transferrin, lactoperoxidase, growth factors, …) *(Berthon and Salmon, 1993; Csapo et al., 1995; Csapo et al., 1995; Kohn et al., 1989)*. Local intestinal protection is provided by IgA while the role of the other factors has not yet been clearly defined.

## Causes and consequences of FTP

Complete FTP (IgG < 4g/l) occurs in 3 to 22% of foals. According to the farm management conditions (sanitary conditions, weather, general health of the herd), morbidity in these foals varies from 0 to 80%. In a large scale French study, 50% of foals with low IgG (< 4 g/l) became ill (half of them died) versus only 5% for well immunised foals (IgG > 8 g/l) *(Génin and Clément, 1989)*. Another retrospective study indicated that 48% of foals with complete FTP had an infectious disease (septicaemia, arthritis, diarrhoea...) in the first weeks *(Mc Guire et al., 1977)*. Other studies have produced similar conclusions *(Chavatte and Collobert, 1994; Robinson et al., 1993)*.

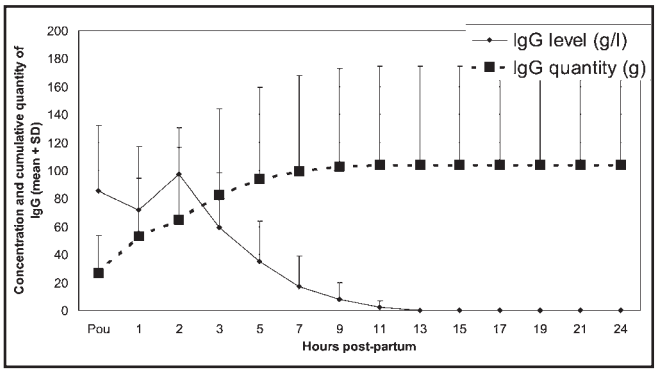


**Fig. 1:** Colostrum IgG (g/l) concentration and cumulative IgG (g) production in 27 saddlemares milked every three hours post-partum (Pou = foaling).

*Kolostrum IgG (g/l) Konzentration und kumulative IgG (g) Produktion bei 27 Stuten, die alle drei Stunden post partum gemolken wurden (Pou = Abfohlung)*

*Low quality colostrum*

This is the most important cause of FTP. The mammary gland concentrates IgG from maternal blood in the last 2 to 4 weeks prior to parturition. High quality colostrum contains about 80 g/l IgG versus 20 g/l in serum. One to 2 litres of colostrum is secreted at the beginning of lactation and is then gradually replaced by milk. By 12 hours post-partum, colostrum IgG concentrations have become negligible if the foal suckled properly *(Jeffcott, 1974; Massey et al., 1991)*. Colostrum quality varies enormously between mares *(Chavatte et al., 1998; Leblanc et al., 1992; LeBlanc and Tran, 1987)*. Colostrum is considered to be high quality if IgG concentrations > 60 g/l, mediocre between 40 and 60 g/l and low when IgG < 40 g/l *(LeBlanc and Tran, 1987)*. About 1/3 of mares produce low quality colostrum *(Génin, 1990; LeBlanc et al., 1986; Leblanc et al., 1992)*. Older mares (> 15 years old) secrete low quality colostrum *(Leblanc et al., 1992)*. In addition, draft mares may produce better colostrum than saddle mares *(Chavatte et al., 1998; Leblanc et al., 1992)*. 67% and 45% of the foals receiving low or mediocre colostrum, respectively, subsequently have FTP *(Clément et al., 2000)*. In contrast, less than 5% of those receiving high quality colostrum develop FTP *(LeBlanc et al., 1986; Leblanc et al., 1992)*. There is a poor correlation between colostrum quality measured for the same mare over subsequent years (0.31, $p < 0.05$) and it cannot be trusted *(Clément et al., 2000)*.

*Delay in suckling*

The foal sucks its dam within 1-2 hours after birth and gut closure will occur by 24 to 36 hours although there is maximum absorption before 8 hours *(Jeffcott, 1974)*. In order to be adequately immunised, a foal should ingest 1.5 l of high quality colostrum or 1 g of IgG per kg bodyweight before 12 hours *(Massey et al., 1991)*.

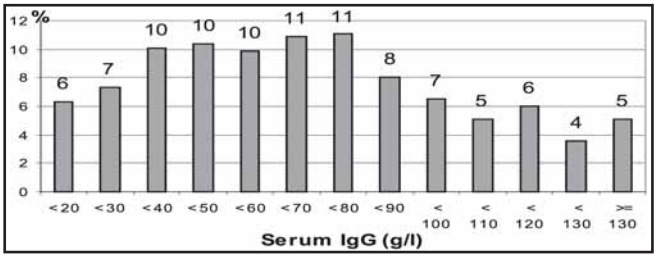


**Fig. 2:** Percentage of mare according to colostrum quality (after *Clément et al., 2000*)

Prozentualer Anteil an Stuten im Verhältnis zur Kolostrumqualität (nach *Clément et al., 2000*)

*Lack of absorption of IgG*

A lack of absorption by the gut has been described in stressed, premature foals *(Koterba, 1990; Rossdale and Ricketts, 1980)*. This has not been verified and the rapid use of ingested and absorbed IgG by these foals may also be responsible for the lack of increase in serum IgG concentrations.

## When to suspect and how to diagnose FTP?

*Risk factors*

Both the measurement of colostrum quality at birth and the time of first suck are needed to estimate the risk of FTP.

Colostrum quality must be measured just after foaling and before the first suck (pre-foaling samples are not reliable). Both mammary glands give the same result *(Clément et al., 2000)*. A honey-like, thick colostrum is usually better than a white, liquid colostrum but these criteria can be rather subjective *(Chavatte et al., 1998)*. The estimation of colostrum density (d > 1.06 for high quality colostrum) with a colostrometer *(LeBlanc, 1984; Leblanc et al., 1992)* is helpful but it can be difficult to obtain reliable measurements under field conditions *(Chavatte et al., 1998; Dascanio et al., 1995)*. The Colotest[1] is a sugar refractometer with an IgG scale (figure 3) which provides an easy, rapid and reliable estimate for colostrum quality *(Chavatte et al., 1998; Clément et al., 2000)*.

*Diagnosis*

Plasma IgG levels can be measured by 12 hours after birth in the foal *(Massey et al., 1991)*, which allows colostrum supplementation before the gut closure. A rapid semi-quantitative test, the CITE Foal[2], can be used in the field and gives results within 10 minutes. The zinc sulfate turbidity test is cheap but can give false positive results.

[1] Colotest : Poly-labo, 39 av d'Iéna, 75783 Paris cedex 16, tel : 01 47 20 36 36, fax : 01 47 23 50 56, www .polylabo.com

[2] Laboratoires Idexx, BP 232, 95614 - Cergy Pontoise

## Prevention and treatment of FTP

*Care and management*

Colostrum quality and time for first suck must be noted. In case of delay, if the suckling reflex is present, 250 to 500 ml of colostrum can be milked from one mammary gland and given to the foal with a baby's feeding bottle in one or two sessions. This can also be performed in a normal situation shortly after birth as long as the foal has a suckling reflex and is standing or maintained in sternal recumbency. In the absence of a suckling reflex, a nasal tube should be used. In all cases, 1–1.5 litres of good quality colostrum should be administered in doses of 200–500 ml if the foal cannot suck or if the dam's colostrum is of low quality or at risk for neonatal isoerythrolysis.

Other authors recommend that the mare be washed and moved to a different box just prior to foaling and that the udder and perineum of the mare be washed just after birth in order to prevent infectious diseases *(Madigan, 1998)*. This is not practical and may disturb maternal bonding and should be performed only in cases of extreme risks of contagion.

**Fig. 3:** Colotest® used to measure colostrum quality

*Colotest®: Gerät zur Messung der Qualität des Kolostrums*

*Vaccination of the dam*

It is generally advised to give a vaccination booster to mares 3–4 weeks prior to term to increase the concentration of specific IgG in colostrum.

*Oral supplementation*

As mentioned above, gut closure occurs 24–36 hours post-natally but IgG are best absorbed within 12 hours after birth. Therefore, before 24 hours of age, 1 to 1.5 g IgG per kg bodyweight can be administered to prevent FTP. Above this level, the absorptive capacity appears to be saturated. Colostrum storage is necessary to always have some ready when needed. Approximately 250 ml of good quality colostrum can be milked from a normal mare after the foal's first suck and frozen at –20°C until use. Colostrum must be thawed before use in a waterbath and should not be kept frozen more than one year. One to 1.5 litres should be administered if the foal does not absorb any other colostrum, whereas 250 to 500 ml may be sufficient if the foal sucks its dam's colostrum which is of low quality.

In a large farm, a local colostrum bank may not be sufficient and other sources of IgG may be needed. Bovine colostral IgG are poorly absorbed, have a short half-life and do not protect against specific equine pathogens: it is therefore not ideal *(Chong et al., 1991; Lavoie et al., 1989; Leblanc, 1991)*. Freeze-dried IgG[3] found on the market have been isolated from serum and are not as effective as complete colostrum replacer *(Touboul et al., 1997)*. In contrast, they are useful in cases of partial FTP, as observed in the bovine species *(Garry et al., 1996)*. Moreover, some products available in the USA are very variable in quality *(Franz et al., 1998)*.

Freeze-dried colostrum itself is a good colostrum replacer *(Touboul et al., 1997)*. It is necessary, however, to check the quality of the colostrum used. A freeze-dried extract of colostral IgG has recently been tested and gives satisfactory immune protection *(Chavatte-Palmer et al., 2001)*. It may become available in the next few years.

The use of oral plasma is less efficient as a large quantity is needed due to the lower IgG concentrations of plasma compared to colostrum and to the fact that serum IgG are poorly absorbed *(Touboul et al., 1997)*. Administration of oral hyperimmune serum may be possible but results need to be confirmed *(Franz et al., 1998; Vivrette et al., 1998)*.

*The gut closure*

When IgG can be absorbed through the gut, bacteria may also enter through the intestine, thus creating a risk for a colostrum deprived-foal awaiting oral treatment. It has been suggested that the absorption of nutrients immediately after birth would accelerate gut closure and therefore decrease the risk of infection through the absorption of bacteria, but that it would also decrease colostral absorption thereafter *(Madigan, 1998)*. A recent study in our laboratory shows that colostral IgG administered 9 hours after birth are equally absorbed whether or not the foal has ingested milk before. Plasma IgG levels at one day of age were about 20% lower, however, compared to foals that received the same quantity of IgG directly after birth.

*Parenteral supplementation*

After 24 hours, parenteral solutions of locally-collected serum or commercially available hyperimmune serum available must be used to treat FTP *(Franz et al., 1998)*. Some of these plasma are produced in horses with specific vaccination programs for E. coli that provide added protection against endotoxemia, but they do not provide antibodies against local pathogens. Plasma can be collected locally from an adult horse with serum IgG >12 g/l and infused to the foal. It is necessary to avoid donor horses with aA or Qa[4] antigens that may sensitise the receiver. The foal must be given 0.2 to 0.4 g IgG per kg bodyweight (for average quality plasma, this is about 20 to 40 ml/kg in a slow IV).

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