uterine prolapse, the expulsion of the uterus externally through the vaginal canal, is an uncommon problem in mares, but its presentation is a challenging and life-threatening emergency. There are multiple suggested causes and correlations to uterine prolapse in mares, but none have been confirmed in a compiled case study. The condition has been suggested to be associated with dystocia, anesthesia, retained fetal membranes, abortions, and postpartum straining or tenesmus.1

In mares, the uterus is suspended in the abdominal cavity by the broad ligament, which attaches to the dorsal aspect of the uterus and cervix. Around the time of foaling, there is a relaxation of supporting structures of the uterus, and the broad ligament elongates to accommodate the increase in uterine volume and weight.1 Compared with nonpregnant mares, pregnant mares are predisposed to uterine prolapse because of this relaxation of the supporting structures combined with increased uterine size and occurrences of uterine contractions.

To our knowledge, uterine prolapse was first reported in several short communications in the early 1970s and 80s1-12 and later in case reports13-21 describing the presentation and treatment of individual cases from 1981 to 2011. The aim of the study reported here was to describe uterine prolapse in mares, including predispositions and outcomes: foal survival to hospital discharge, mare survival to hospital discharge, and future fertility of affected mares.

OBJECTIVE
To describe uterine prolapse, predispositions, and outcomes in mares treated between 1988 and 2019.

ANIMALS
24 mares with uterine prolapse.

PROCEDURES
Clinical records were retrospectively reviewed, and follow-up information was gathered. The Mann-Whitney U test and Fisher exact test were used to analyze results for history and outcome variables for potential association with mare survival to hospital discharge. The χ² test was used to compare breed distribution.

RESULTS
Age was known in 23 mares (median, 11.1 years). For 15 mares with exact known parity, the median parity was 3 births (range, 1 to 13 births). For 22 mares, the maiden status was known (7 [32%] maiden; 15 [68%] multiparous). Breed distribution differed significantly between mares with uterine prolapse and all mares treated at the Veterinary Medical Teaching Hospital. Arabians were overrepresented in the uterine prolapse group (7/24 [29%]), compared with all mares treated (4,174/44,474 [9%]). Uterine prolapse occurred within 2 hours after parturition for 10 of 11 mares with known foaling times, after dystocia for 7 mares, and after abortion for 4 mares. Seventeen of 23 (74%) mares survived to hospital discharge. Acute hemorrhage was the most frequent cause of death. There were no correlations between mare survival to hospital discharge and mare parity or age, foal sex, retained fetal membranes, sepsis, or maiden status. Colts were overrepresented in foals with a known sex (12/17).

CLINICAL RELEVANCE
Results indicated a breed predisposition to uterine prolapse, with Arabian mares overrepresented among affected mares. No characteristics correlated with mare survival to hospital discharge.
Materials and Methods

Clinical records from the William R. Pritchard Veterinary Medical Teaching Hospital, University of California-Davis (VMTH) were searched and reviewed in an online record system (Veterinary Medical and Administrative Computer System [VMACS], University of California-Davis) for records of horses with the key words “uterus,” “uterine,” or “prolapse” anywhere in the patient record. Identified records were reviewed by board-certified theriogenologists, and follow-up health and breeding information was gathered when possible. For each mare with uterine prolapse during the study period, data were collected pertaining to the mare (breed, age, parity, maiden status, and survival to hospital discharge), pregnancy and parturition (gestational length and foaling characteristic), and foal (sex, size, and survival to hospital discharge). Prolapse data included location of uterine replacement (VMTH or field) and presence (yes or no) of attached fetal membranes. In addition to mare survival to hospital discharge (yes or no), occurrence of severe blood loss (yes or no) or transfusions (yes or no) was also recorded. Total and ionized blood calcium concentrations as documented in VMACS were also reviewed. When multiple laboratory results were available in 1 visit record, the results from the sample obtained closest to the timeframe of uterine prolapse were used. Data from several other variables, including mare body weight and results of blood work, placenta pathology or histopathology, and bacterial cultures performed on uterine samples, were collected but not included in the study analysis due to lack of consistent reporting in the records. History of previous breeding, foaling characteristics, and future rebreeding information was collected from mare owners, breeding associations, and referring veterinarians, when possible.

Statistical analysis

Data about parity, gestational length, breed distribution, and blood calcium concentrations were analyzed for normality using the Shapiro-Wilk Test (JMP, version 14.0, SAS Institute Inc). The number of mares seen by the VMTH during the study period was obtained for each breed for investigation of breed representation in the VMACS system. The period prevalence of uterine prolapse was calculated for the VMTH mare population and by breed using the following formulas:

Overall period prevalence of uterine prolapse (%) = \[
\frac{\text{No. of mares with uterine prolapse}}{\text{No. of mares examined at VMTH}} \times 100
\]

Period prevalence of uterine prolapse by breed (%) = \[
\frac{\text{No. of mares by breed with uterine prolapse}}{\text{No. of mares by breed examined at VMTH}} \times 100
\]

Statistical analysis of breed distribution for mares with uterine prolapse was compared with the general mare population using a \(\chi^2\) test for breeds represented by \(\geq 5\) mares with uterine prolapse. Breeds with \(< 5\) mares with uterine prolapse were classified as “other” for \(\chi^2\) analysis. Mann-Whitney \(U\) calculation and Fisher exact test were performed with available software (Prism, version 8.0, GraphPad Software Inc) to assess differences in mare survival to hospital discharge for mares grouped by variables of interest. Values of \(P \leq 0.05\) were considered significant for all analyses. Data were presented as the mean \(\pm SD\) unless otherwise specified.

Results

Twenty-four mares with uterine prolapse were presented to the VMTH from 1988 to 2019. Two mares had a history of previous uterine prolapse prior to the case reported in this study. Two other mares came from the same owners, but the prolapse occurred years apart. The overall period prevalence of uterine prolapse in the population of mares seen at the VMTH was 0.05\% (Table 1). Pearson \(\chi^2\) analysis revealed a significant \((P < 0.05)\) difference in breed distribution between mares with uterine prolapse and all mares presented to the VMTH. Arabian mares were significantly \((P < 0.01)\) overrepresented in the uterine prolapse group \((7/24 [29\%])\), compared with all mares seen at the VMTH \((4,174/44,474 [9\%])\).

No significant differences in breed distribution were identified for American Quarter Horse \((P = 0.76)\) or Thoroughbred \((P = 0.81)\) representations for mares with uterine prolapse versus all mares seen at the VMTH. Due to low case numbers \((n < 5)\), specific statistical comparisons were not made for Tennessee Walkers, Friesians, Appaloosas, Shires, Shetland Ponies, or Standardbreds, and those breeds were collectively classified as other.

Investigation of breed-specific prevalence revealed the highest period prevalences of uterine prolapse in Shires \((1.27\% [1/79])\), Tennessee Walkers \((0.66\% [2/302])\), and Shetland Ponies \((0.63\% [1/160])\), followed by Friesians \((0.17\% [1/593])\), Arabians \((0.17\% [7/4,174])\), Appaloosas \((0.10\% [1/1,042])\), and Standardbreds \((0.10\% [1/1,051])\). The lowest period prevalences of uterine prolapse was observed in Thoroughbreds \((0.05\% [5/10,177])\) and American Quarter Horses \((0.05\% [5/10,438])\).

Age at the time of uterine prolapse was known for 23 mares, and the age distribution was evaluated (Figure 1). The mean \(\pm SD\) age at the time of uterine prolapse was 11.1 \(\pm 4.6\) years \((range, 4 [n = 3] to 23 [1] years)\). Parity data were not normally distributed, and the history of parturition was not available for 2 mares. Parity was known for 22 mares, of which 7 (32\%) were maiden mares and 15 (68\%) were primiparous or multiparous mares. The mean \(\pm SD\) parity was 3 \(\pm 2.7\) births \((median, 3 births; interquartile [25th to 75th percentile] range [IQR], 1 to 5 births; range, 1 [n = 7] to 13 [1] births)\). Of the 7 maiden mares, 2 were >10 years old.

Gestational length data were not normally distributed. The specific gestational length was known for 11 mares, with a median gestational length of

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Table 1

<table>
<thead>
<tr>
<th>Breed</th>
<th>No. of Mares Known for Parity</th>
<th>Prolapse Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arabian</td>
<td>7</td>
<td>29%</td>
</tr>
<tr>
<td>Tennessee Walker</td>
<td>2</td>
<td>29%</td>
</tr>
<tr>
<td>Shetland Ponies</td>
<td>1</td>
<td>63%</td>
</tr>
<tr>
<td>Friesian</td>
<td>1</td>
<td>17%</td>
</tr>
<tr>
<td>Appaloosa</td>
<td>1</td>
<td>10%</td>
</tr>
</tbody>
</table>

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S81
319 days (range, 150 to 364 days). For 18 mares, foaling status was classified as either term delivery (n = 14) or abortion (n = 4). Three of the 24 (13%) mares prolapsed during general anesthesia for either management of dystocia (n = 2) or during abdominal surgery for a postpartum colon torsion (the uterus was partially prolapsed prior to anesthesia; 1). The latter was then euthanized during surgery.

Dystocia status was known for 21 of the mares with uterine prolapse, 7 (33%) of which had dystocia. Time of foaling relative to prolapse was known for 11 mares, and uterine prolapse occurred within 2 hours after foaling for 10 mares, of which 9 mares had uterine prolapse within 1 hour after foaling. The status of attached placenta was reported for 19 mares, of which 12 had the fetal membranes attached. The location where the uterus was repositioned (ie, in the field vs at the VMTH) was recorded for 19 mares, with the uterus repositioned in the field for 11 mares and at the VMTH for 8 mares.

In the records for 13 of the 24 mares, results for blood calcium concentrations were available in the VMACS. Three records contained results for total and ionized blood calcium concentrations, 9 records had results for total blood calcium concentration alone, and 7 records had results for ionized blood calcium concentration alone. Normal distribution of total and ionized blood calcium concentrations was confirmed. Mean total blood calcium concentration for all mares with data available was 10.9 ± 0.958 mg/dL (n = 9), and mean ionized blood calcium concentration was 1.34 ± 0.179 mmol/L (n = 7). Six of the mares with low blood calcium concentrations were also classified as mares with severe blood loss.

Status of whether mares survived to hospital discharge was known for 23 mares, of which 17 (74%) survived to discharge, whereas 6 did not.

Table 1—Breed distributions for mares with uterine prolapse (n = 24) versus all mares (44,474) treated at the William R. Pritchard Veterinary Medical Teaching Hospital, University of California-Davis between 1988 and 2019, and the calculated period prevalence of uterine prolapse in mares during the study period.

<table>
<thead>
<tr>
<th>Breed group</th>
<th>Mares with uterine prolapse</th>
<th>All mares</th>
<th>Uterine prolapse period prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of mares</td>
<td>Percentage (95% CI)</td>
<td>No. of mares</td>
</tr>
<tr>
<td>All breeds</td>
<td>24</td>
<td>100 (—)</td>
<td>44,474</td>
</tr>
<tr>
<td>Arabian</td>
<td>7</td>
<td>29 (15–49)</td>
<td>4,174</td>
</tr>
<tr>
<td>QH</td>
<td>5</td>
<td>21 (9.2–40)</td>
<td>10,438</td>
</tr>
<tr>
<td>TB</td>
<td>5</td>
<td>21 (9.2–40)</td>
<td>10,177</td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
<td>29 (15–49)</td>
<td>3,207</td>
</tr>
<tr>
<td>Tennesse Walker</td>
<td>2</td>
<td>8 (2.3–26)</td>
<td>302</td>
</tr>
<tr>
<td>Friesian</td>
<td>1</td>
<td>4 (0.7–20)</td>
<td>593</td>
</tr>
<tr>
<td>Appaloosa</td>
<td>1</td>
<td>4 (0.7–20)</td>
<td>1,042</td>
</tr>
<tr>
<td>Shire</td>
<td>1</td>
<td>4 (0.7–20)</td>
<td>79</td>
</tr>
<tr>
<td>Shetland Pony</td>
<td>1</td>
<td>4 (0.7–20)</td>
<td>160</td>
</tr>
<tr>
<td>Standardbred</td>
<td>1</td>
<td>4 (0.7–20)</td>
<td>1,031</td>
</tr>
</tbody>
</table>

QH = Quarter Horse. TB = Thoroughbred.

*95% CIs computed using score confidence intervals.
— = Not calculated.
(nonsurvivors). Of the nonsurvivors, 5 died from acute severe hemorrhage, and 1 died during postpartum colic surgery (uterus prolapsed during the surgery). Another mare died 6 months later of secondary peritonitis and adhesions.

The most common complication after uterine prolapse was acute severe hemorrhage (12/22 [55%]). Of the 12 mares with acute severe hemorrhage, 7 survived to hospital discharge, whereas 5 did not survive despite treatment. Seven mares received full blood transfusions, and 5 of these 7 mares survived. In contrast, the proportion of mares that survived to hospital discharge was much higher for the mares that did not have severe hemorrhage (9 of 10 mares survived and 1 mare died during colic surgery). Secondary to uterine prolapse, 8 mares developed sepsis, and 2 mares had full-thickness uterine tears.

The status of whether foals survived to hospital discharge was known for 23 cases, of which 15 (65%) were discharged alive. The sex of the foal was documented in the records for 17 of which 12 were colts and 5 were fillies. Only 1 colt foal, 65-kg Thoroughbred colt, was reported to have been larger than clinically normal. Four of the 22 colts were delivered prematurely (<320 days of gestation), and 8 of the 22 colts were reported to have been of clinically normal or small size (compared with the respective breed standards) at the time of foaling.

No statistically significant relationship was identified between parity (P = 0.32) or age (P = 0.61) and mare survival to hospital discharge. There was no statistically significant correlation between mare survival to hospital discharge and sex of the foal (P > 0.99), place of uterine replacement (P > 0.99), retained fetal membranes (P > 0.99), occurrence of sepsis (P = 0.18), or incidence of maiden status (P = 0.26). Although not significant (P = 0.16), severe hemorrhage was more common in mares that were nonsurvivors (5/6) versus survivors (7/17).

Follow-up information was available for 14 of the mares. Only 5 of the 14 mares were rebred, and 4 later foaled successfully. Of these 4 mares, 1 lost 2 successive foals in dystocias before producing a live foal (a mule foal). One mare that survived to hospital discharge died 6 months later due to adhesions in the abdomen.

Discussion

For the mares in the present study, we found no substantial correlation between survival to hospital discharge and mean ± SD age (11.1 ± 4.6 years) or parity (3 ± 2.7 births). The 22 mares with known parity consisted of 7 (32%) maiden mares and 15 (68%) primi- or multiparous mares. The percentage of maiden mares could have been similar for mares for all mares seen at the VMTH during the study period, but as the present study was retrospective, there was no control group to allow a proper comparison between groups. Previous reports describe parity of mares with uterine prolapse as maiden (n = 3), 1,11,16,23 a 1-year-old prepubertal maiden (1), 20 or multiparous (1). 14 Contrary to our findings, data from those reports suggest that maiden mares may be at a higher risk of uterine prolapse during parturition than may mares of other parities.

Interestingly, we found that breed distribution differed significantly for mares with uterine prolapse versus all mares seen at the VMTH during the same time period. Arabian mares were significantly overrepresented in the uterine prolapse group (7/24 [29%]), compared with all mares seen at the VMTH (4,174/44,474 [9%]). Arabian mares have been associated with overrepresentation in cases of prepubic tendon ruptures, 22 and a speculative relation between the 2 conditions is excessive broad ligament relaxation or stretching around the time of foaling, causing increased likelihood for rupture of the prepubic tendon and of prolapse. Because low case numbers limited statistical analysis investigating breed predispositions to Arabians, American Quarter Horses, and Thoroughbreds, the overall period prevalence of uterine prolapse was calculated for all breeds for additional comparison. Four breeds (Friesian, Shire, Tennessee Walker, and Shetland Pony) had higher period prevalences of uterine prolapse than Arabians, but each was represented by ≤ 2% of the mares seen at the VMTH (Table 1) and by only 1 mare with uterine prolapse. Further studies with higher case numbers would be beneficial to investigate predisposition to uterine prolapse in these breeds.

Previous reports on equine breeds with uterine prolapse included 2 hunters, 5,6 2 donkeys, 7,10 1 Percheron, 4 2 ponies, 21 1 Thoroughbred, 14 4 Shires, 11 1 Appaloosa, 16 1 American Quarter Horse, 13 1 warmblood, 20 1 Selle Français, 15 1 Trakehner, 18 and 2 Arabians. 15,17 Contrary to our results, these publications do not suggest a clear influence of the breed and suggest that horses of many breeds may be affected by this condition.

Most mares with known foaling times prolapsed the uterus within 1 to 2 hours after foaling, before the membranes are normally considered to be retained. Based on this information, and in agreement with other authors, 23 we do not believe there is a direct relation between retained fetal membranes and uterine prolapse. However, the expulsion of fetal membranes combined with attached membranes pulling on the tip of uterine horns may contribute to the pathogenesis. In the present report, 12 of 19 mares had the fetal membranes attached when the uterus prolapsed. Friesians and draft mares 23 are known to have an increased likelihood of retained fetal membranes, but in the study, there was just 1 Shire and 1 Friesian with uterine prolapse. Case numbers were too low for statistical analysis.

When considered by foaling characteristics, 33% (7/21) of the mares in the present study prolapsed following dystocia, 4 of 18 mares with gestational length known prolapsed following abortion, and 13% (3/24) prolapsed during general anesthesia. Of the occurrences of uterine prolapse during anesthesia, 2 occurred during management of dystocia, and 1 occurred during abdominal surgery for a postpartum colon torsion. This mare was reported to have a partial prolapse prior to surgery and was later
euthanized during surgery. When dystocias are managed in mares under general anesthesia, the uterus is more likely to prolapse due to the positioning of the mare in dorsal recumbency, relaxation of the muscles, open cervix, and pressure of the abdominal organs. It is therefore recommended to exert care when the foal is pulled from the mare. Likewise, surgery in postpartum mares has previously been described as a risk factor for uterine prolapse, and some authors suggest placement of towel clamps in the vulvar lips when the mare is positioned in dorsal recumbency to reduce this risk.1

Foaling characteristics were reported in some previous case reports, including 7 eutocias,5,6,8,12,16,17,21 3 dystocias,2,4,10 4 abortions,3,15–15 and 1 nonfoaling yearling.20 Similar to the findings in our study, these results support that uterine prolapse may occur after eutocia, dystocia, or abortions. In previous reports, dystocias represent 7.9% (36/456) in American Quarter Horse,13.7% (54/395) in Thoroughbred,26 and 11.2% (58/517) in mixed-breed20 foaling populations. Dystocias occurred more frequently (33% [7/21]) in the mares of the present study than in the aforementioned foaling populations. Abortions have been reported to occur in 8.7% (175/2,000) of an equine pregnancy population,27 whereas abortions represented 22% (4/18) of the cases in our study. We propose that abortion and dystocia may predispose to uterine prolapse in mares; however, the present study did not have a control group. The cause of abortion was known in 3 of the 4 mares: 1 aborted with twins on approximately day 150 of gestation, 1 aborted due to glycogen branching deficiency syndrome on approximately day 289 of gestation, and 1 aborted after having been covered by a stallion in a shared paddock on approximately day 270 of gestation.

Sex distribution among the foals was uneven with a higher proportion of colts (12/17) than fillies (5/17). This could have been explained by the relatively longer gestation and bigger size of colts; based on that assumption, there is a higher potential for increased difficulty and straining during the delivery of colts, compared with fillies. However, only 1 colt foal was reported to have been larger than clinically normal, 65-kg Thoroughbred colt. Four of the colt foals were delivered prematurely (< 320 days of gestation), and 8 of the colt foals were reported to have been of clinically normal or small size (compared with the respective breed standards) at time of foaling.

Two mares in the study had a previous history of uterine prolapse, and 2 other mares came from the same farm. This may suggest individual or environmental risk factors, similar to those of 4 Shires with uterine prolapse seen by the same veterinarian between 1939 and 1942.11

Mare survival to hospital discharge was good overall (17/23 [74%]), with 7 of 12 mares that survived acute, severe hemorrhage and 9 of 10 mares that did not develop acute, severe hemorrhage after the uterine prolapse surviving to hospital discharge. Of the mares with substantial hemorrhage after uterine prolapse (12/22), 7 received full blood transfusion, and 5 of these 7 mares survived to hospital discharge. Hemorrhage during uterine prolapse can occur from rupture of a uterine artery or directly through the endometrium. The proportion of mares that survived to hospital discharge in the present study (17/23 [74%]) was comparable with findings published previously for case reports (9/14 [64%])2–12 and peer-reviewed papers (8/9 [89%]).13–21 In these previous reports, 2 mares died after rupture of the uterus,4,11 1 died after prolapsing the intestines along with the uterus,5 and 1 mare died of septic shock during anesthesia,18 and the cause of death for the remaining 2 mares was unreported.

Etiology, prognosis, treatment, and prevention of uterine prolapse are well described in dairy and beef cattle systems and are mentioned here for comparison. In dairy cattle, heifers are generally at lower risk of uterine prolapse compared to multiparous cows, and the risk of uterine prolapse is increased in cases of clinical milk fever and stillbirths.28–30 The incidence of hypocalcemia has been studied extensively in dairy cattle,30 supporting the close correlation to uterine prolapse through causing uterine atony. Similarly, uterine atony and hypocalcemia have been proposed previously as etiologic factors in horses, and the presence of low (total) blood calcium concentration has been confirmed in mares with uterine prolapse.15,18 The mean ± SD blood calcium concentrations (total calcium, 10.9 ± 0.958 mg/dL; n = 9; and ionized calcium, 1.34 ± 0.179 mmol/L; 7) in the mares of the present study were below the reference limit for adult horses, which may have suggested hypocalcemia as a factor for horses as well. However, the blood calcium concentrations were measured at various times during hospitalization for mares of the present study, and the acute conditions of the mares may have contributed to the hypocalcemic condition. Six of the mares with low blood calcium concentrations in the present study were also classified as mares with severe blood loss. Because severe blood loss and hemoperitoneum may also cause low blood calcium concentration,41 it is not possible to make any conclusion on the correlation between hypocalcemia and uterine prolapse in horses based on the present study. Further studies are needed to verify whether hypocalcemia is a predisposing factor for uterine prolapse in horses.

In beef cattle with dystocias, uterine prolapse is more common in heifers than in multiparous cattle,12 and the risk of uterine prolapse is more closely related to forced traction on the calf than it is to hypocalcemia. Richardson et al12 suggest that the uterus is likely to be pulled out with the calf in the case of forced traction and that prolonged down time after calving as a result of dystocia increases the risk of the uterus to prolapse. In camels, uterine prolapse is closely related to vitamin E and selenium deficiency, also known as white muscle disease.33,34 White muscle disease causes an overall decrease in muscle function that may lead to poor uterine tone along with poor fitness and immune system function. Selenium deficiency has also been suggested as a reason for uterine atony in horses and may contribute
as a risk factor to uterine prolapse. Selenium values were not available for any mares in the present study; therefore, further studies are needed to determine a relationship between selenium deficiency and the risk of uterine prolapse in the mare.

Prognosis of uterine prolapse in dairy cattle is generally considered good, with survival of 66% (19/30 died within 24 hours, further 16 died or were lost to follow-up) to 74% (50/68) of affected cattle. Chance of recovery was significantly better in heifers if the calf was born alive and in the absence of milk fever. Future fertility is good, with conception rates reported of 84% (36/43).

The prognosis for survival in these cattle reports is similar to our findings in horses (74% [17/23] survival to hospital discharge). The good future fertility reported in cattle is also consistent with follow-up information collected in our study, showing that 4 of the 5 mares that were rebred following prolapse foaled successfully. Prevention of uterine prolapse in cows is aimed at preventing milk fever, abortion, stillbirth, and white muscle disease, but immediate postpartum prophylactic treatment has also been suggested in high-risk cows. Prevention of alkalosis, vitamin D deficiency, and hypocalcemia, along with reduced intake of potassium and sufficient dry matter intake, has been suggested to reduce milk fever. Prevention of abortion and stillbirth can be achieved through herd health and vaccination programs, and for beef heifers, it is important to select for low birthweight to prevent dystocias that require forced traction. Reports show no link to repetitive incidence of uterine prolapse in cattle. Chance of recovery was significantly better in heifers if the calf was born alive and in the absence of milk fever.

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