A rapid review of evidence of infection of dogs and cats with human associated corona virus SARS, MERS and COVID-19 and evidence of the fomite potential of dogs and cats

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Date started: Thursday March 19, 2020
Date 1st version published: Friday March 20, 2020 2:16 pm
Date updated: Saturday March 21, 2020 5:50 pm (see page 2 for changes)

Summary:
A rapid review was undertaken for two questions of interest to veterinarians related to COVID-19. As little evidence is available, we also assess other known human corona viruses, SARS and MERS.

Question 1:
“What is the evidence that cats or dogs can be infected with the human-associated corona viruses SARS, MERS and COVID-19?”

Key findings:
Only three studies (Table 1) evaluating infection of cats or dogs with human-associated corona viruses were found. All three evaluated SARS. One study reported that 2 cats housed with 6 SARs infected cats had detectable viral titers within 2 days and seroconverted to the virus within 28 days(1). There was no report of viral shedding in the two housed cats. The 6 inoculated cats did shed virus based on pharyngeal swabs. These 6 cats animals were inoculated by the intra-tracheal route with 106 median tissue-culture infectious dose units (TCID50), which were obtained from a patient who died from SARS and then passaged four times on Vero 118 cells in vitro.

SARS was detected in a longitudinal observational study conducted at an animal market in China which included sampling of domestic cats (2). Four of 36 cats tested were positive; all positives were very early in the study period. The third study on cats was not relevant, as it did not assess natural routes of infection but rather described a SARS challenge model(3).

In contrast, there are several studies of infection with Ebola in dogs and MERS in camels, which indicated that the search strategy was able to identify such studies for human corona virus if they were in the literature.

Hong Kong Government officials have report that two dogs living with COVID-19 infected owners have tested PCR positive to COVID-19 (4, 5). One dog tested positive on oral and nasal samples. No details were provided about the other dog samples. Neither dog showed clinical signs. These reports have little detail about testing and samples.

Question 2:
“What is the evidence that cats or dogs can act as a fomite for human-associated corona viruses SARS, MERS and COVID-19?”

Key findings:
No studies were found that evaluated fur, hair, skin, or hides as a source of transmission from cats or dogs for the SARs, MERS or COVIS-19. In contrast, there are several studies on dogs for Ebola and MERS in camels, which indicated that the search was able to identify such studies.
Update: 4:40 pm 20th March 2010. There are press reports from the Hong King Government that some dogs have tested positive to COVID-19 in homes with COVID-19 human patients. These reports have little detail about testing and samples.

https://www.info.gov.hk/gia/general/202003/04/P2020030400658.htm


Approach:

Eligibility:
- Eligible populations: domestic cats and dogs
- Exposure of interest: human-associated corona viruses SARS, MERS and COVID-19
- Q1 Outcome of interest: Evidence of infection with SARS, MERS or COVID-19 based on antibodies or PCR in saliva or serum
- Q2 Outcome of interest: Detection of SARS, MERS and COVID-19 on the hair or fur of cats or dogs.

Search:

The searches were conducted on Thursday 19th March using all databases in the Michigan State University Web of Science Interface (Table 3). Due to the concern about designing the search quickly for an area with very few potentially relevant studies, positive control terms were included in the searches to provide some validation for the search strategy. For Question 1, because we were aware that literature exists that identified dogs that were antibody positive to Ebola, and because we were aware that literature exists about camel owners and MERS, we also conducted a search using identical search terms to our human corona virus search, but first replacing the outcome with “Ebola” and then including “camels” in the population terms. The concept behind the positive controls is to ensure that studies of similar type were captured.

Information sources:

The databases searched are listed in Table 3. The search strings used are reported in Table 2 We also hand searched the 626 results using on-line title screening in BioRxiv and MedRxiv to identify pre-publications using the search string "(COVID-19 OR SARS-CoV-2 OR SARS OR MERS) AND (cat OR dog)". We also searched ProMed Mail (https://promedmail.org/promed-posts/) – using the following search strings and results:

- Ebola AND dog = no relevant results found
- Ebola AND cat = 0 results
- SARS-CoV AND cat= 0 results
- SARS-CoV AND dog = 0 results
- SARS AND cat = 1 result found, but not relevant (related to civet cat ban).
- MERS And dog = 0
- MERS AND cat = 0
- MERS AND camel = 75
- COVID AND dog = 5 results
- COVID AND cat = 0

Screening:
For question 1, the screening question asked if the study reported either MERS, SARS or COVID-19 or Ebola (positive control) in dogs or cats.
For question 2, the screening question asked if the study reported either MERS, SARS or COVID-19 or Ebola (positive control) on the fur, hair, or skin in dogs or cats.
Screening was conducted by two reviewers, with only one person required to reject or accept. We used the Distiller SR® AI tool to evaluate automated screening for question 2. The decision rule for using the AI reviewer, was that when the AI tool indicated that it had “0 incorrect excludes”, it was used. The setting was for the AI to exclude studies it considered irrelevant and then a human reviewer evaluated the remaining studies.

Results:

**Question 1:** “What is the evidence that cats or dogs can be infected with the human-associated corona viruses SARS, MERS and COVID-19?”

532 studies were found in the search and 5 ProMED-mail reports. The AI reviewer was not used. Only three studies (Table 1) evaluating infection of cats or dogs with human-associated corona viruses were found. All three evaluated SARS. One study reported that 2 cats housed with 6 SARS infected cats had detectable viral titers within 2 days and seroconverted to the virus within 28 days(1). There was no report of viral shedding in the two housed cats. The 6 inoculated cats did shed virus based on pharyngeal swabs. These 6 cats animals were inoculated by the intra-tracheal route with 106 median tissue- culture infectious dose units (TCID50), which were obtained from a patient who died from SARS and then passaged four times on Vero 118 cells in vitro.

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**Question 2:** “What is the evidence that cats or dogs can act as a fomite for human-associated corona viruses SARS, MERS and COVID-19?”

The search for literature for dogs and cats as fomites found 797 citations. AI was utilized after the human reviewers has screen 414 citations with 6 considered relevant. The AI reviewer excluded all but 98 citations, which then were evaluated by a human; none of these were relevant. In total, 6 relevant studies were identified, all related to Ebola. No studies were found that evaluated fur, hair, skin, or hides as a source of transmission from cats or dogs for SARS, MERS or COVID-19. In contrast, there are several studies on dogs for Ebola and MERS in camels, which indicated that the search was able to identify such studies.
**Table 1: Studies investigating infection of domestic cats with SARS virus.**

<table>
<thead>
<tr>
<th>Manuscript</th>
<th>Summary of finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. E. E. Martina et al, SARS virus infection of cats and ferrets, Nature, 425: 915-915, 2003. 10.1038/425915a</td>
<td>Experimental infection study: Full text Non-inoculated cats and ferrets housed with cats and ferrets inoculated with SARS became infected with SCV: viral titres gradually increased from 2 days post inoculation onwards, peaking at days 6–8 post inoculation. Neither of the cats showed clinical signs of infection, but both had seroconverted by day 28 (they had virus-neutralizing antibody titres of 40 and 160, respectively).</td>
</tr>
<tr>
<td>Ming Wang et. al., Surveillance on severe acute respiratory syndrome associated coronavirus in animals at a live animal market of Guangzhou in 2004, Zhonghua liuxingbingxue zazhi, 26: 84-87, 2005</td>
<td>Observational study: Abstract only This study looked at naturally infected cats at multiple times points. Jan 2004: 4 of 20 sampled cats were infected with SARS-CoV like virus by RT-PCR methods Jan 20 204: 0 of 13 cats were infected April, May, June, July, Aug., Nov, Dec: 0 of 3 cats and 0 of 5 dogs were infected.</td>
</tr>
<tr>
<td>J. M. A. Van den Brand et al, Pathology of experimental SARS coronavirus infection in cats and ferrets, Veterinary Pathology, 45: 551-562, 2008</td>
<td>Not relevant. Cats were evaluated for pathology of SARS, but the route of infection was not aerosol.</td>
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Table 2: Search strategy details used for the rapid review in Michigan State University Web of Science

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<th>#8</th>
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<td></td>
<td>Databases= WOS, BIOABS, BCI, CABI, CCC, DRCI, DIIDW, FSTA, KJD, MEDLINE, RSCI, SCIELO, ZOOREC Timespan=All years Search language=Auto</td>
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<td></td>
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<td>#6</td>
<td>TS=(skin OR fur OR hair OR fomite OR &quot;direct contact&quot; OR petting OR Patting OR brushing OR saliva OR hide OR leather OR grooming OR fomites)</td>
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<td></td>
<td>Databases= WOS, BIOABS, BCI, CABI, CCC, DRCI, DIIDW, FSTA, KJD, MEDLINE, RSCI, SCIELO, ZOOREC Timespan=All years Search language=Auto</td>
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<td>Databases= WOS, BIOABS, BCI, CABI, CCC, DRCI, DIIDW, FSTA, KJD, MEDLINE, RSCI, SCIELO, ZOOREC Timespan=All years Search language=Auto</td>
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<td></td>
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<td>TS= (&quot;Middle east respiratory syndrome&quot; OR MERS OR MERS-CoV OR SARS OR SARS-CoV OR &quot;sudden acute respiratory syndrome&quot; or COVID OR COVID-19 OR EBOLA OR EVD)</td>
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<td></td>
<td>Databases= WOS, BIOABS, BCI, CABI, CCC, DRCI, DIIDW, FSTA, KJD, MEDLINE, RSCI, SCIELO, ZOOREC Timespan=All years Search language=Auto</td>
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Search updated 21st March
Search string modified: 21st March #6 “OR fomites”

Table 3: Citations Databases in the Michigan State University Library Collection in the Web of Science interface.

| Web of Science Core Collection | (1900-present) |
Science Citation Index Expanded (1900-present)
Social Sciences Citation Index (1900-present)
Arts & Humanities Citation Index (1975-present)
Conference Proceedings Citation Index - Science (1990-present)
Conference Proceedings Citation Index - Social Science & Humanities (1990-present)
Book Citation Index – Science (2005-present)
Book Citation Index – Social Sciences & Humanities (2005-present)
Emerging Sources Citation Index (2005-present)
Current Chemical Reactions (1985-present)
(Indexes Institut National de la Propriete Industrielle structure data back to 1840)
Index Chemicus (1993-present)
