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FELINE INFECTIOUS PERITONITIS

FIP

THE RISE OF COVID & THE FALL OF FIP

Tiarni Johnston BVSc (Hons) MANZCVS (SAM)

Internal Medicine Resident



Microsoft Stock Photo

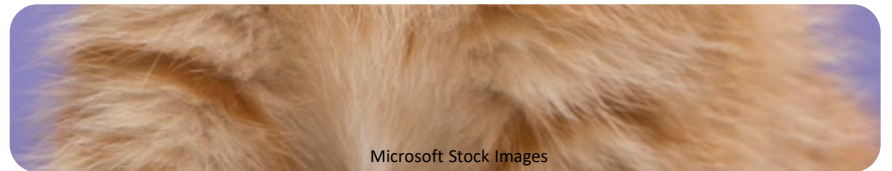


OUTLINE

1. What is FIP?
2. Diagnosis
3. Treatment
4. Prognosis
5. Prevention



What is Feline Infectious Peritonitis?





WHAT IS FELINE INFECTIOUS PERITONITIS?

Feline Enteric Coronavirus (FECoV)

Epidemiology



Ubiquitous
in cats
worldwide.

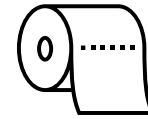


Enzootic in
virtually all
larger multicat
environments

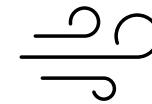


>50% healthy cats &
80% of cats with
diarrhoea from high-risk
environments =
shedders over any given
time

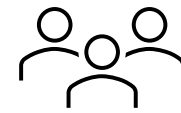
Transmission



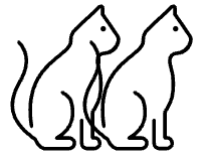
Shared
litter
trays.



Litter
dust on
fomites.



Virus on
people
handling
cats.



Direct
contact
between
shedding
cats.





WHAT IS FELINE INFECTIOUS PERITONITIS?

FECoV Infects 2 Groups of Cats

Increased FECoV replication → increased risk of FIP developing

Kittens at ~9 weeks old
(<9 weeks old if high
environmental viral load)

Disease occurs when exposure is
high and innate immune
defences are weakened.



Older cats (i.e. 10+ years)
associated with a weakening
immunity

Only strong adaptive immune
responses will prevent viral replication
and possibly disease development.





WHAT IS FELINE INFECTIOUS PERITONITIS?

Feline Enteric Coronavirus

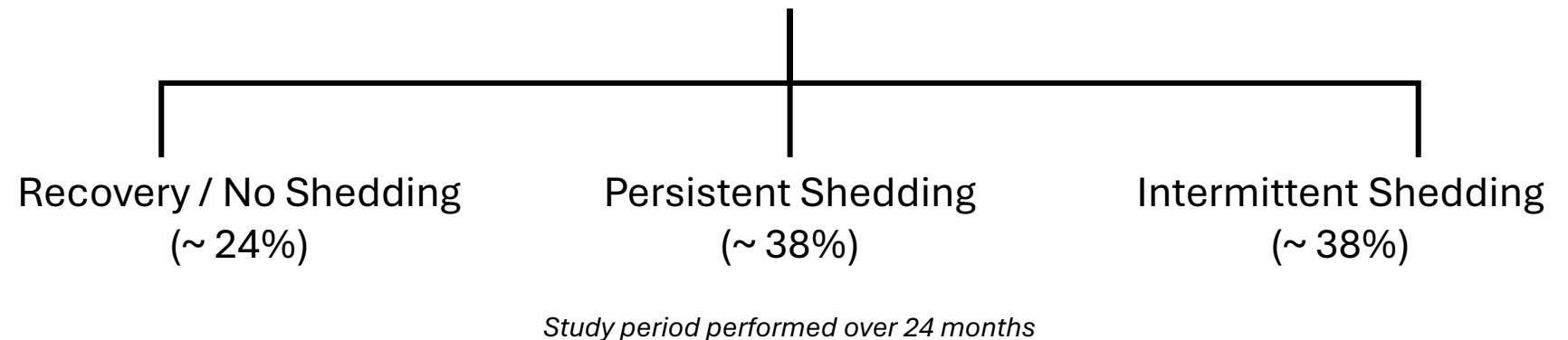
There is a distinct primary stage of infection (~ 7 - 18 months)
→ the highest level of virus shedding occurs during this stage.



ELSEVIER

Pathogenesis of feline enteric coronavirus infection

Niels C Pedersen, Claire E Allen, Leslie A Lyons



Of all cats that are infected with FECoV → **< 5% develop FIP**





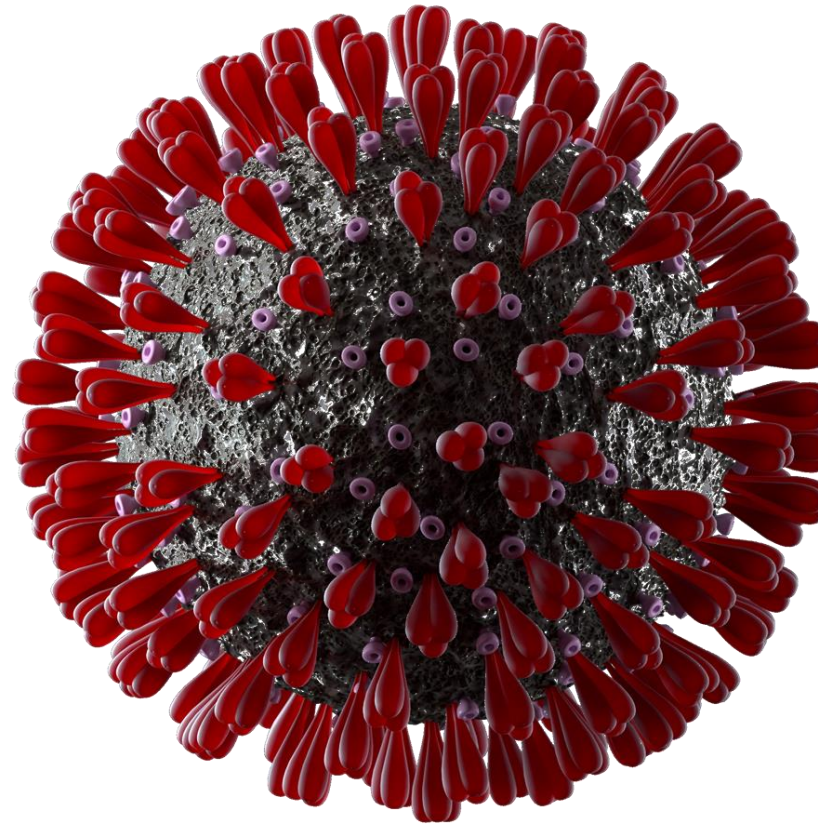
WHAT IS FELINE INFECTIOUS PERITONITIS?

Feline Coronavirus (FCoV) – Biotype One

Feline Enteric
Coronavirus
(FECoV)

VERY Contagious

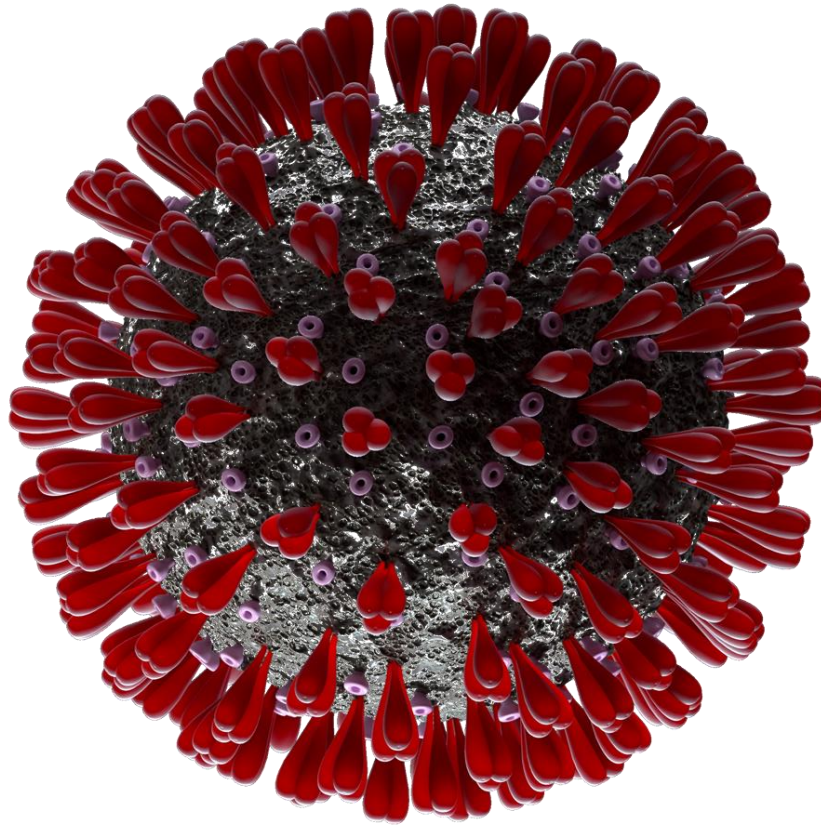
Virus found
frequently in the
faeces of healthy
cats.





WHAT IS FELINE INFECTIOUS PERITONITIS?

Feline Coronavirus (FCoV) – Biotype Two



Feline Infectious
Peritonitis
(FIPV)

NOT Contagious

Virus found in tissues
and effusions of cats
with FIP.





WHAT IS FELINE INFECTIOUS PERITONITIS?

Feline Enteric
Coronavirus

So how do we get from
FECoV to FIP?

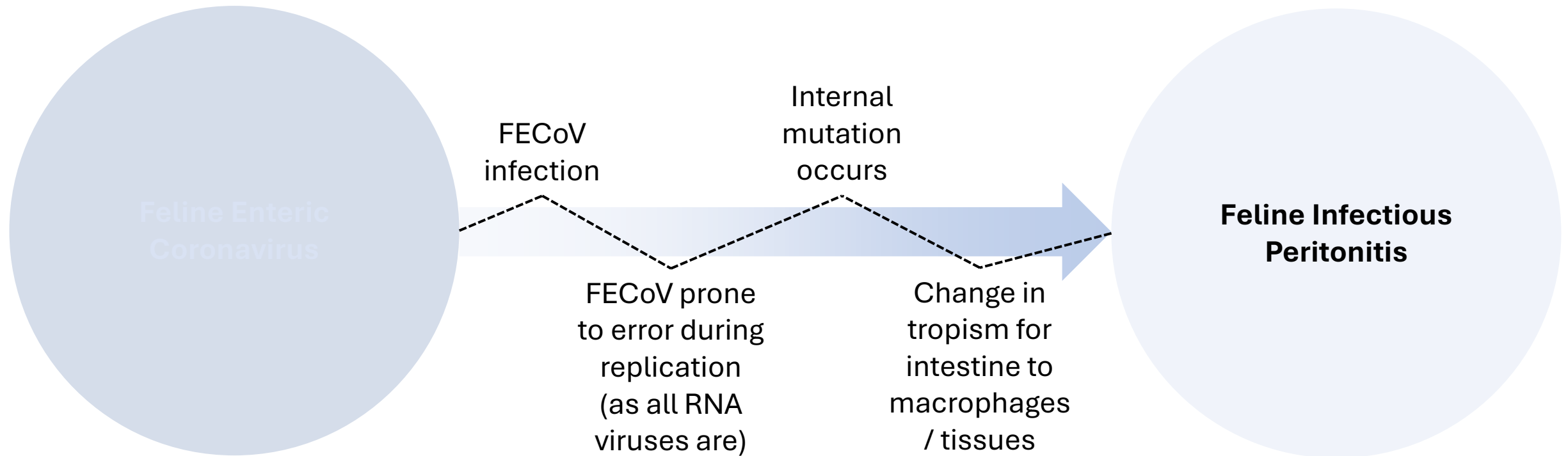
Feline Infectious
Peritonitis





WHAT IS FELINE INFECTIOUS PERITONITIS?

Internal Mutation Hypothesis



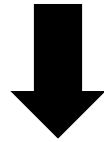


OUTBREAKS?

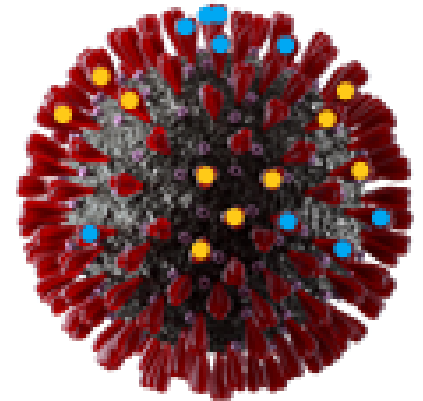
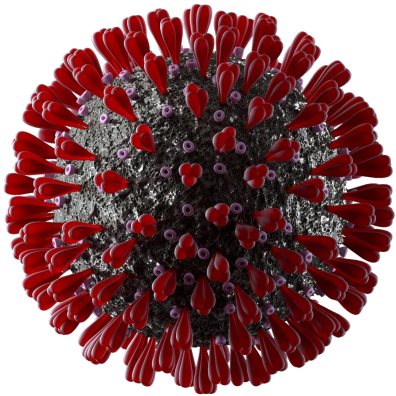
Internal Mutation
Hypothesis

+

Circulating Strain
Hypothesis



Increasing evidence that multiple mutations
are required to change tropism.
So, if you have a strain of FECoV already with
 ≥ 1 mutations \rightarrow FIP is more likely to develop in
multiple individuals at once.

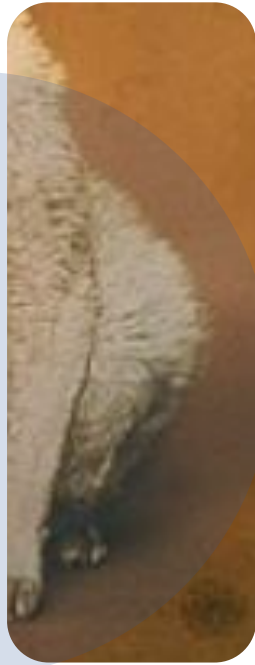




WHAT IS FELINE INFECTIOUS PERITONITIS?



Abdominal Effusion

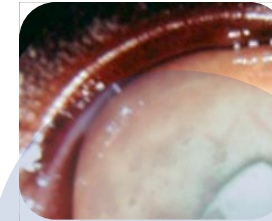


Effusive “Wet” Form

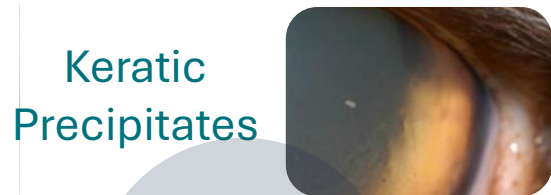
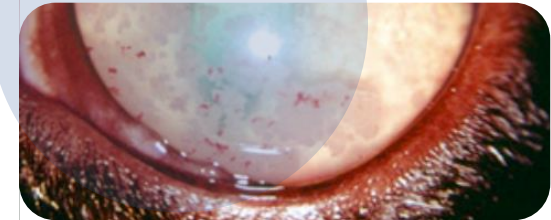
- The classic presentation of FIP
- Results in a viscous effusion within body cavities

Non-Effusive “Dry” Form

- Focal and organised granulomatous lesions in organs
 - Mesenteric lymph nodes, caecum, colon, kidney, lungs, pericardium, eyes, brain / spinal cord, and miscellaneous sites.
- Inflammatory lesions induced by FCoV (pyogranulomatous vasculitis)



Perivascular Retinal Lesions

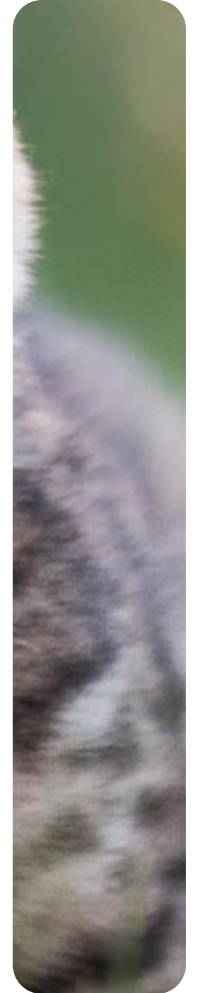
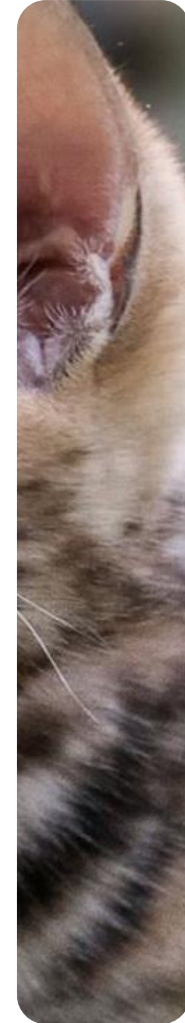


Keratic Precipitates






How is FIP Diagnosed?





HOW IS FIP DIAGNOSED?



**Presumptive
Diagnosis**



**Highly
Suspicious**



**Definitive
Diagnosis**





PRESUMPTIVE DIAGNOSIS

Baseline Diagnostics:

1. Signalment
2. Disease History
3. Physical Examination Abnormalities
4. CBC & Serum Chemistry
5. Effusion/Tissue Assessment



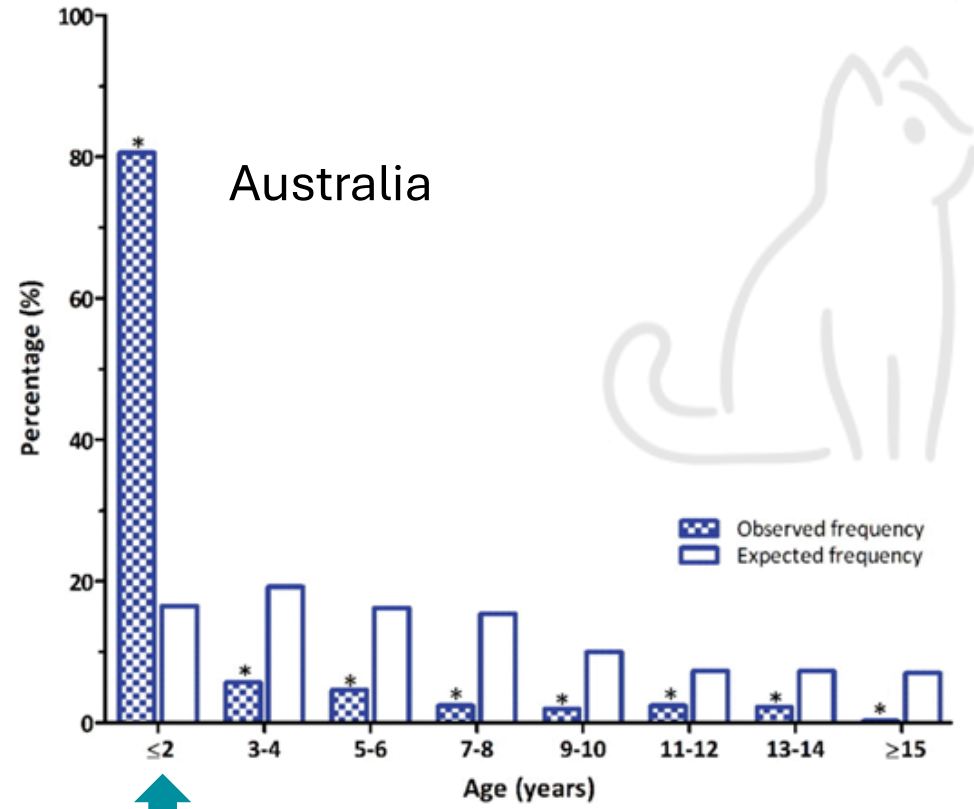
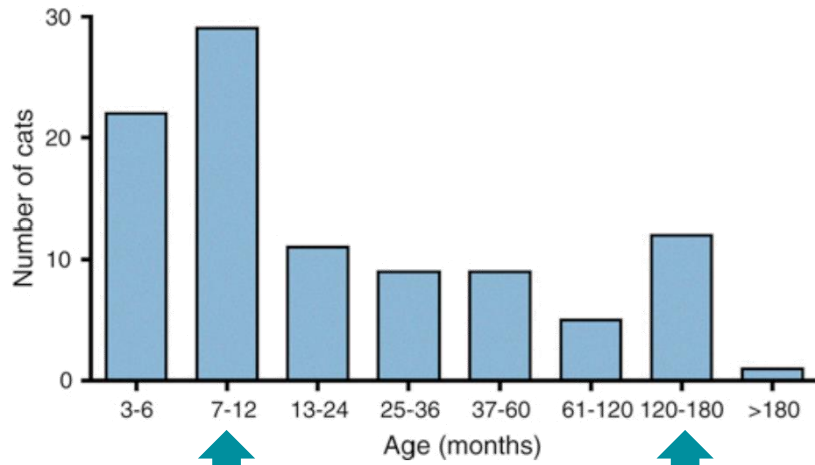
This is often enough for a presumptive diagnosis.





PRESUMPTIVE DIAGNOSIS

Signalment: Age:
Europe & The Americas





PRESUMPTIVE DIAGNOSIS

Signalment

Breed:

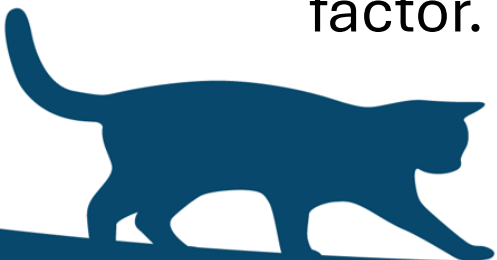
- Cats of any breed or age can develop FIP.
- Often in pedigree cats.

Sex / Neuter Status:

- In some studies, males are more likely to develop FIP than females.

Genetic Factors:

- Inbreeding = the most significant genetic risk factor.



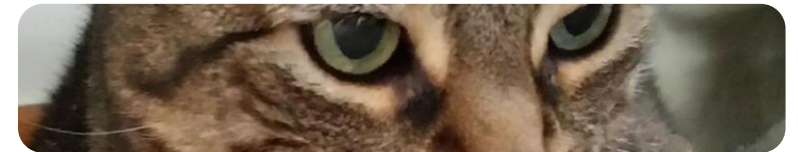


PRESUMPTIVE DIAGNOSIS

Disease History

The median duration of clinical signs before diagnosis is approximately 10 days
(Range: 1–210 days) (Coggins, SJ. et al. 2023)

Clinical signs are variable → depending on whether the patient has effusive or non-effusive disease





PRESUMPTIVE DIAGNOSIS

Retrospective study and outcome of 307 cats with feline infectious peritonitis treated with legally sourced veterinary compounded preparations of remdesivir and GS-441524 (2020-2022)

Samantha S Taylor, Sally Coggins, Emi N Barker, Daniëlle Gunn-Moore, Kamalan Jeevaratnam, Jacqueline M Norris, David Hughes, Emily Stacey, Laura MacFarlane, Carolyn O'Brien, Rachel Korman, Gerard McLauchlan, Xavier Salord Torres, Aimee Taylor, Jos Bongers, Laura Espada Castro, Max Foreman, James McMurrough, Bethany Thomas, Emilie Royaux, Isabel Calvo Saiz, Guido Bertoldi, Caroline Harlos, Megan Work, Cameron Prior, Stephanie Sorrell, Richard Malik, Séverine Tasker

Clinical History:

Findings are variable and depend on whether the patient has wet or dry disease.

The findings to the left are based on BOTH presentations combined



Original Article



| Clinical Sign | Percentage |
|----------------------|------------|
| Lethargy | 93.8 |
| Inappetence | 75.5 |
| Weight loss | 42.8 |
| Abdominal distension | 28.1 |
| Neurological Signs | 20.3 |
| Diarrhoea | 15 |
| Ocular Signs | 13.1 |
| Respiratory Signs | 12.1 |
| Vomiting | 7.8 |



PRESUMPTIVE DIAGNOSIS

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Physical Examination:

Findings are variable and depend on whether the patient has the wet or dry manifestation of the disease.

The findings to the left are based on BOTH presentations combined



Original Article



jfms
Journal of Feline
Medicine and Surgery

| Physical Exam Finding | Percentage |
|-----------------------|------------|
| Pyrexia | 57.2 |
| Abdominal Effusion | 38.9 |
| Poor BCS (<3/9) | 38.1 |
| Jaundice | 19 |
| Neurologic Deficits | 17 |
| Tachypnoea | 13.7 |
| Ocular Abnormalities | 13.1 |
| Abdominal Mass | 10.5 |
| Dyspnoea | 5.2 |
| Dull Heart Sounds | 5.2 |



PRESUMPTIVE DIAGNOSIS

Variability in Clinical Signs of Effusive and Non-Effusive FIP

| | Anatomic Location of Disease | | | | % of Cats | |
|---------------|------------------------------|----------------|--------|--------------|-----------|--------------|
| | Peritoneal Cavity | Pleural Cavity | Ocular | Neurological | Effusive | Non-Effusive |
| One Region | ✓ | | | | 58 | 30 |
| | | ✓ | | | 11 | 1 |
| | | | ✓ | | - | 14 |
| | | | | ✓ | - | 22 |
| Two Regions | ✓ | ✓ | | | 22 | 4 |
| | ✓ | | ✓ | | 2.8 | 7 |
| | ✓ | | | ✓ | 1.9 | - |
| | | | ✓ | ✓ | - | 8 |
| Three Regions | ✓ | ✓ | ✓ | | - | 2 |
| | ✓ | ✓ | | ✓ | <1 | 3 |
| | ✓ | | ✓ | ✓ | <1 | 2 |
| | | ✓ | ✓ | ✓ | <1 | - |

Table adapted from Greene's Infectious Diseases of the Dog and Cat





PRESUMPTIVE DIAGNOSIS

Haematological changes in cats with FIP



Anaemia of chronic inflammation

Inflammatory leukogram

■ % of Cats Below RI
 ■ % of Cats Within RI
 ■ % of Cats Above RI

Information adapted from Greene's Infectious Diseases of the Dog and Cat





PRESUMPTIVE DIAGNOSIS

Serum Biochemical changes in cats with FIP

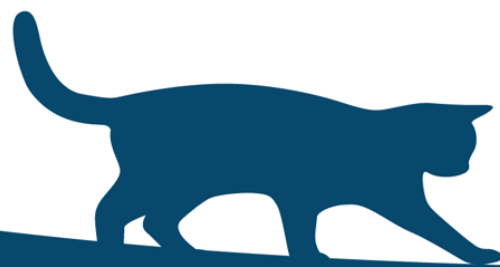
Increased bilirubin

Alb:Glob Ratio

- % of Cats Below RI
- % of Cats Within RI
- % of Cats Above RI

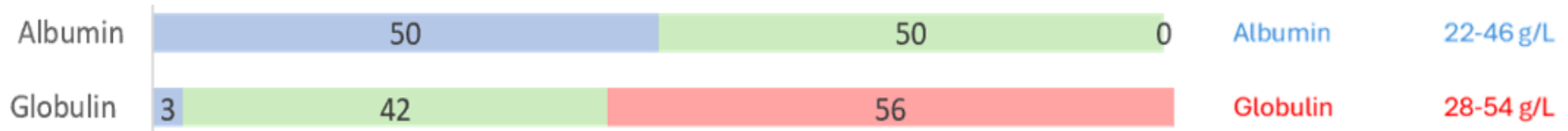


Information adapted from Greene's Infectious Diseases of the Dog and Cat





PRESUMPTIVE DIAGNOSIS



Albumin : Globulin Ratio

The A:G ratio in FIP cats is frequently below normal (<0.6)

Serum A:G ratio >0.6 → FIP is less likely.

Serum A:G ratio <0.6 → FIP is more likely but not definitive.

The predictive value of the A:G ratio is only dependent on the presence of other clinical findings associated with FIP.





PRESUMPTIVE DIAGNOSIS

Effusion Analysis:



Free peritoneal or pleural fluid is one of the most diagnostic clinical features in cats with FIP (effusive form).



Classic effusions are:

- Yellow tinged (or blue-green)
- Cloudy
- High protein
- WBCC >3000 cells/ μL ($>3 \times 10^9/\text{L}$)
- Viscous (egg white-like consistency), contains fibrin tags, and frequently forms partial clots when in a serum tube.

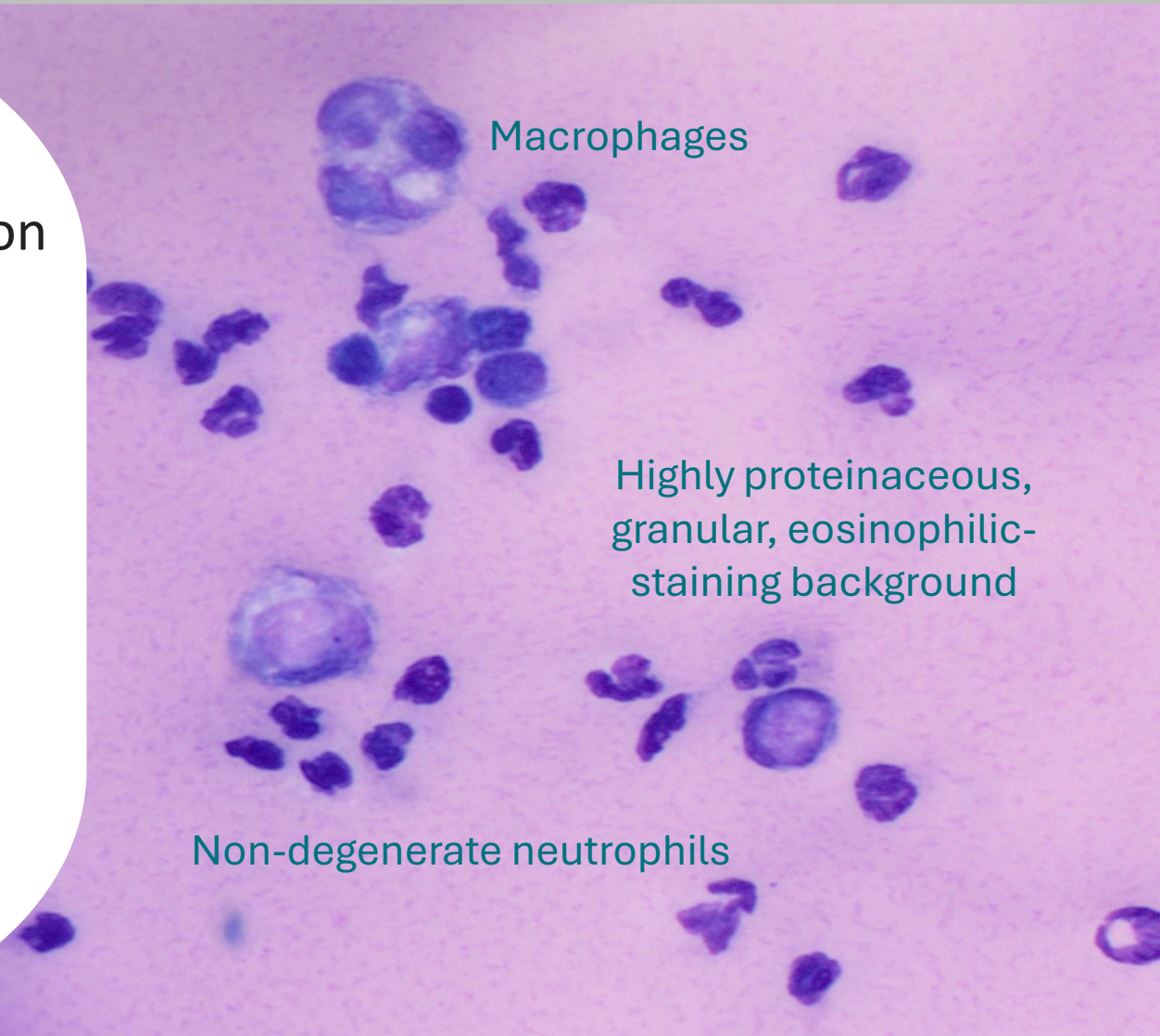


PRESUMPTIVE DIAGNOSIS

Effusion Analysis: Cytology

Typical findings on cytological evaluation of FIP effusion include:

1. A highly proteinaceous, granular, eosinophilic-staining background
2. Non-septic pyogranulomatous inflammation
 1. Macrophages
 2. Non-degenerate neutrophils
 3. Very few lymphocytes



Cytology courtesy of
NovaVet Diagnostics





PRESUMPTIVE DIAGNOSIS

Effusion fluid



Acetic Acid

Image from Green's Infectious Diseases of the Dog and Cat



Adobe Stock Image

Effusion Analysis: Rivalta Test

What is the Rivalta Test?

Rivalta test for the diagnosis of FIP were lower than previously reported except when used in young cats <2 years of age.

- Se 91.3%
- Sp 65.5%
- NPV 93.4%
- PPV 58.4%

Values from Fischer Y, et al. Diagnostic accuracy of the Rivalta test for feline infectious peritonitis. Vet Clin Pathol. 2012 Dec; 41(4): 558–567.

The components in effusions that lead to a positive Rivalta test are unknown (suspect proteins), with positive test results also occurring in cats with bacterial peritonitis or lymphoma.





PRESUMPTIVE DIAGNOSIS

Physical Exam

All of these consistent findings are required to make a presumptive diagnosis



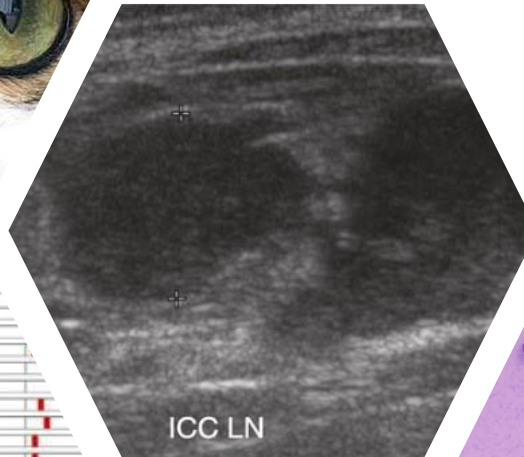
Signalment

Clinical Signs



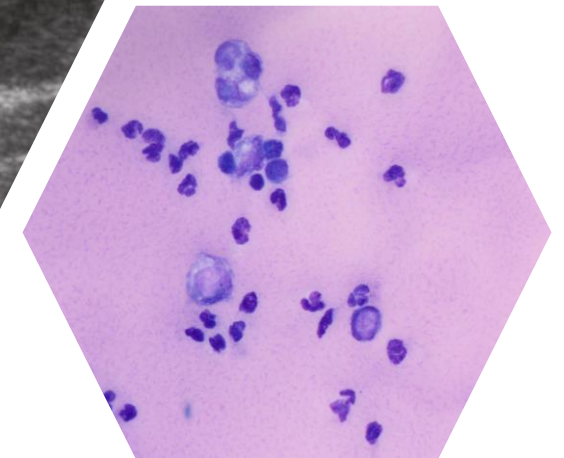
Blood Findings

| | Result | Reference Range | Low | High |
|-------|--------|------------------|------|------|
| ALB | 5 | 0 - 62 U/L | | |
| ALP | 45 | 28 - 100 U/L | | |
| BUN | 74 | 5 - 55 U/L | HIGH | |
| CREAT | 512 | 64 - 440 U/L | HIGH | |
| GLUC | 2 | 0 - 6 U/L | | |
| HEM | 2.0 | 2.3 - 3.9 g/dL | LOW | |
| TBL | 9.4 | 5.9 - 8.5 g/dL | HIGH | |
| TBL | 7.4 | 3.0 - 5.6 g/dL | HIGH | |
| TBL | 1.2 | 0.0 - 0.4 mg/dL | HIGH | |
| TBL | 0.5 | 0.0 - 0.2 mg/dL | HIGH | |
| BUN | 21 | 15 - 34 mg/dL | | |
| CREAT | 0.8 | 0.8 - 2.3 mg/dL | | |
| CHOL | 177 | 82 - 215 mg/dL | | |
| GLUC | 112 | 70 - 150 mg/dL | | |
| GLUC | 8.4 | 8.2 - 11.8 mg/dL | | |
| GLUC | 5.4 | 3.0 - 7.0 mg/dL | | |
| PHOS | 13 | 13 - 25 mEq/L | | |
| PHOS | 120 | 111 - 125 mEq/L | | |
| PHOS | 3.7 | 3.9 - 5.3 mEq/L | LOW | |
| PHOS | 148 | 147 - 156 mEq/L | | |
| PHOS | 0.3 | 0.4 - 0.8 | LOW | |
| PHOS | 0.7 | 0 - 0.3 mg/dL | HIGH | |
| PHOS | 40 | | | |




Imaging Findings

Cytology





How is FIP Diagnosed?



**Presumptive
Diagnosis**



**Highly
Suspicious**



**Definitive
Diagnosis**

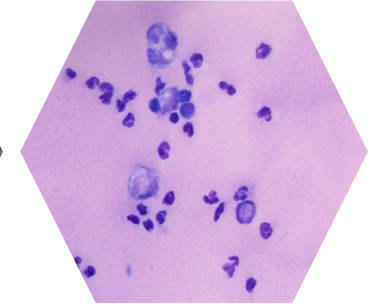
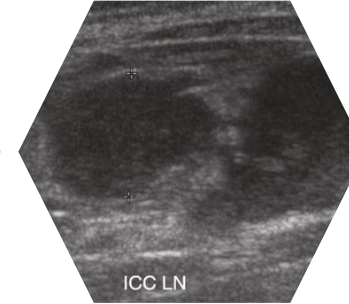




HIGHLY SUSPICIOUS OF FIP



| | Result | Reference Range | Low | Hi |
|----------------|--------|------------------|------|----|
| ATASE | 5 | 0 - 62 U/L | | |
| | 45 | 28 - 100 U/L | | |
| | 74 | 5 - 30 U/L | HIGH | |
| | 512 | 64 - 440 U/L | HIGH | |
| | 2 | 0 - 6 U/L | | |
| ALB | 2.0 | 2.3 - 3.9 g/dL | LOW | |
| ALB/PROTEIN | 94 | 5.9 - 8.5 g/dL | HIGH | |
| ALBU | 74 | 3.0 - 5.6 g/dL | HIGH | |
| TAL BILIRUBIN | 1.2 | 0.0 - 0.4 mg/dL | HIGH | |
| RECT BILIRUBIN | 0.5 | 0.0 - 0.2 mg/dL | HIGH | |
| BUN | 21 | 15 - 34 mg/dL | | |
| CREATININE | 0.8 | 0.3 - 2.3 mg/dL | | |
| COLESTEROL | 177 | 82 - 218 mg/dL | | |
| COSE | 112 | 70 - 150 mg/dL | | |
| TUM | 84 | 8.2 - 11.8 mg/dL | | |
| UREA | 54 | 3.0 - 7.0 mg/dL | | |
| CARBONATE | 13 | 15 - 25 mEq/L | | |
| ? | 120 | 111 - 125 mEq/L | | |
| ? | 3.7 | 3.9 - 5.3 mEq/L | LOW | |
| | 148 | 147 - 156 mEq/L | | |
| | 0.3 | 0.4 - 0.9 | LOW | |
| UBDN | 0.7 | 0 - 0.3 mg/dL | HIGH | |
| | 40 | | | |



All the factors that make up a presumptive diagnosis + “indirect tests” increase the odds that the patient’s clinical signs are due to FIP





HIGHLY SUSPICIOUS OF FIP

FCoV RNA Detection by RT-PCR

*REMEMBER: Cats with FIP
+ healthy cats can
intermittently shed FECoV
antigen.*

*PCR testing of faeces for
FCoV shedding is of
limited value (= FECoV
biotype).*

Most PCR tests do not differentiate between virulent and avirulent FCoV strains

Recent studies show FCoV RNA in tissues outside the gastrointestinal tract \neq FIPV

→ avirulent strains may be found in tissues and blood.

Extraintestinal tissues with:

1. High copy numbers = FIP more likely
2. Low copy numbers = FIP less likely





HIGHLY SUSPICIOUS OF FIP

FCoV RNA Detection by RT-PCR

| Sample Type | Sensitivity | Specificity |
|------------------------------------|---------------|-------------|
| Peripheral blood mononuclear cells | 29% | 100% |
| Serum | 15% | 86-100% |
| Cell-free body cavity effusions | 89% | 89%–100% |
| CSF | 41.5 - 85.7%* | 100% |

* Sensitivity of cats showing ocular and/or neurological signs – Sensitivity was only 41.5% when considering all cats regardless of clinical presentation.



Levels of feline infectious peritonitis virus in blood, effusions, and various tissues and the role of lymphopenia in disease outcome following experimental infection

Niels C. Pedersen^{a*}, Chrissy Eckstrand^c, Hongwei Liu^a, Christian Leutenegger^b, Brian Murphy^c



Detection of feline coronavirus in cerebrospinal fluid for diagnosis of feline infectious peritonitis in cats with and without neurological signs

Journal of Feline Medicine and Surgery
1-6
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http://dx.doi.org/10.1177/1098121515574757
jfms.com
SAGE

Stephanie J Doenges¹, Karin Weber¹, Roswitha Dorsch¹, Robert Fux², Andrea Fischer¹, Lara A Matiassek¹, Kaspar Matiassek² and Katrin Hartmann¹

These sensitivities and specificities are only in association with cats definitively diagnosed with FIP **via other means**.





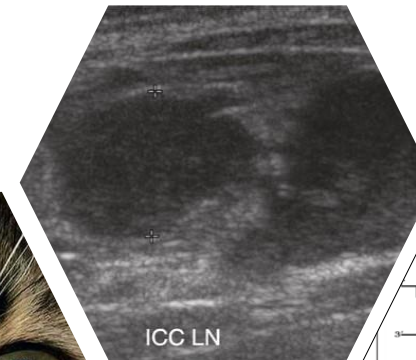
HIGHLY SUSPICIOUS OF FIP

All of these findings are required to be highly suspicious of FIP

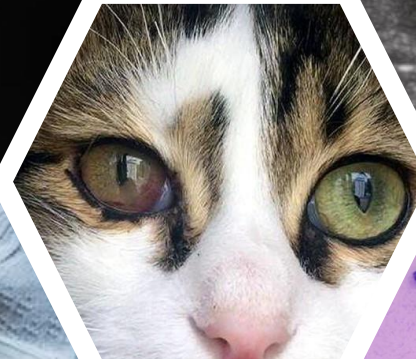
Signalment



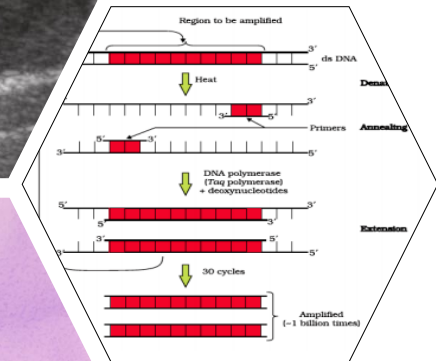
Imaging Findings



Physical Exam



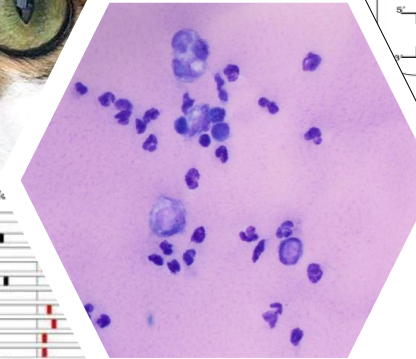
RT-PCR



Clinical Signs

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| | 512 | 64 - 440 U/L | HIGH | |
| | 2 | 0 - 6 U/L | | |
| EN | 2.0 | 2.3 - 3.9 g/dL | LOW | |
| ALBUMIN | 9.4 | 5.9 - 8.5 g/dL | HIGH | |
| BILIRUBIN | 7.4 | 3.0 - 5.6 mg/dL | HIGH | |
| TOTAL BILIRUBIN | 1.2 | 0.0 - 0.4 mg/dL | HIGH | |
| DIRECT BILIRUBIN | 0.5 | 0.0 - 0.2 mg/dL | HIGH | |
| UN | 21 | 15 - 34 mg/dL | | |
| CREATININE | 0.8 | 0.8 - 2.3 mg/dL | | |
| CHOLESTEROL | 177 | 82 - 218 mg/dL | | |
| GLUCOSE | 112 | 70 - 150 mg/dL | | |
| UM | 8.4 | 8.2 - 11.8 mg/dL | | |
| PHOSPHORUS | 5.4 | 3.0 - 7.0 mg/dL | | |
| CHLORIDE | 13 | 13 - 25 mEq/L | | |
| PHOSPHATE | 120 | 111 - 125 mEq/L | | |
| PHOSPHATE | 3.7 | 3.9 - 5.3 mEq/L | LOW | |
| PHOSPHATE | 148 | 147 - 156 mEq/L | | |
| PHOSPHATE | 0.3 | 0.4 - 0.8 | LOW | |
| BILIRUBIN | 0.7 | 0 - 0.3 mg/dL | HIGH | |

Blood Findings




Cytology





HOW IS FIP DIAGNOSED?



**Presumptive
Diagnosis**



**Highly
Suspicious**



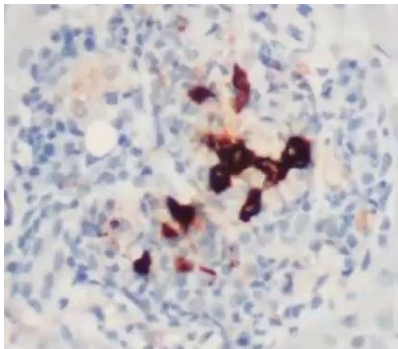
**Definitive
Diagnosis**



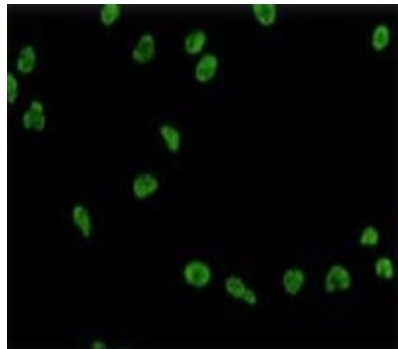


DEFINITIVE DIAGNOSIS OF FIP

FIP Diagnosis IFA and IHC tests: Veterinary Pathology Diagnostic Services, University of Sydney



Immunohistochemistry



Immunocytochemistry

Tests performed thus far have been “indirect tests” which do not provide a definitive diagnosis.

1. “Indirect Tests” → Increase the odds that the CSx are due to FIP, or
2. “Direct Tests” → attempt to provide a definitive diagnosis





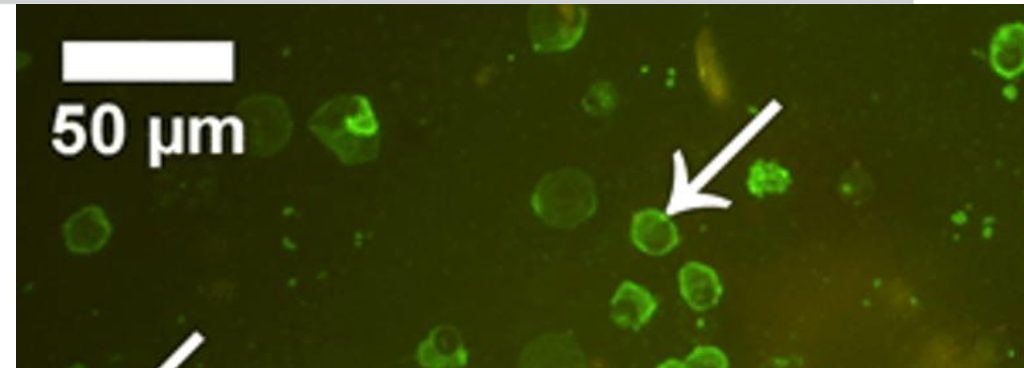
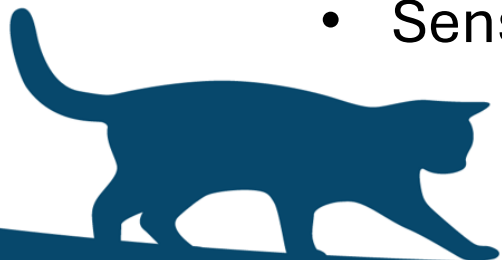
DEFINITIVE DIAGNOSIS OF FIP

Immunocytochemistry

University of Sydney uses direct immunofluorescence (IFA) of effusion fluid or fine needle aspirates to detect the virus within the cytoplasm of macrophages.

Based on studies performed with the university of Sydney:

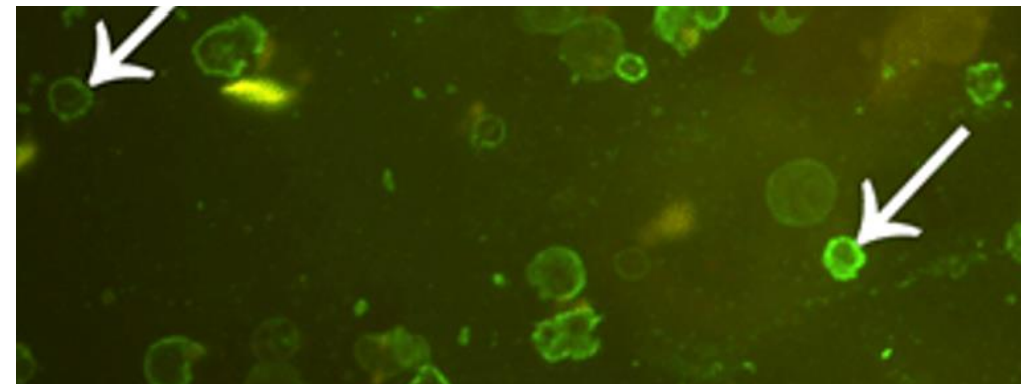
- Specificity: >99%
- Sensitivity: 75%



Immunohistochemical Methods to Diagnose Atraumatic Spleen Rupture in Feline Infectious Peritonitis of Tiger (*Panthera tigris*)

CRISTINA HORHOGEA, VIOREL FLORISTEAN*, MIRCEA LAZAR, CARMEN CRETU, CARMEN SOLCAN
University of Agricultural Sciences and Veterinary Medicine, Faculty of Veterinary Medicine, 8 M. Sadoveanu Alley, 700489, Iasi, Romania

Macrophages and lymphocytes positive for FCoV antibodies (arrows) in pericardial fluid. Direct immunofluorescence test





DEFINITIVE DIAGNOSIS OF FIP

Example Report

SCHOOL OF VETERINARY SCIENCE
VETERINARY PATHOLOGY DIAGNOSTIC SERVICES



Direct Immunofluorescence Report

Several cell preparations (cytospins) were made from the fluid submitted. Using a fluorescein labelled antibody against Feline Coronavirus (types I and II), immunofluorescence was performed to identify the presence of the virus within macrophages seen in the fluid. This was **POSITIVE** for feline coronavirus infected macrophages in the fluid.

Protein Level & Albumin/Globulin Ratios

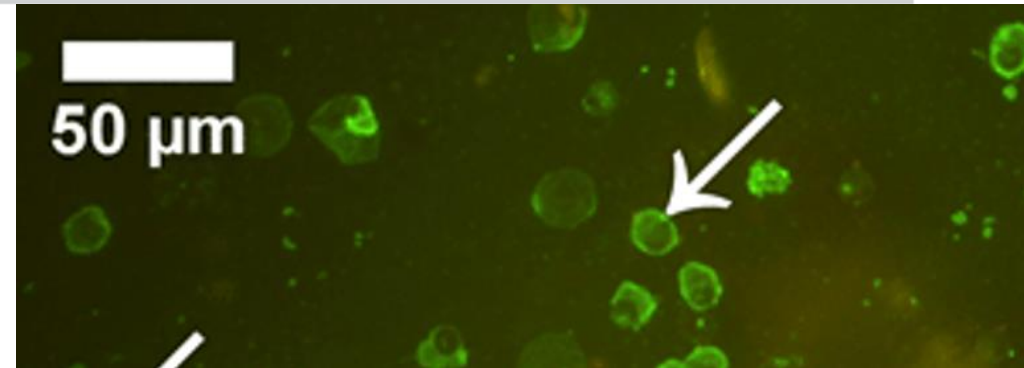
Protein = 73 g/L, Albumin = 16.9 g/L, Globulin = 55.8 g/L. Albumin/globulin ratio = 0.30

CONCLUSION

A diagnosis of FIP is supported by the results of the direct immunofluorescence (IFA) test.

Protein level – a protein level of less than 30g/L is highly unlikely to be FIP. A protein level above 30 g/L can be seen in many diseases including FIP and so is non-specific.

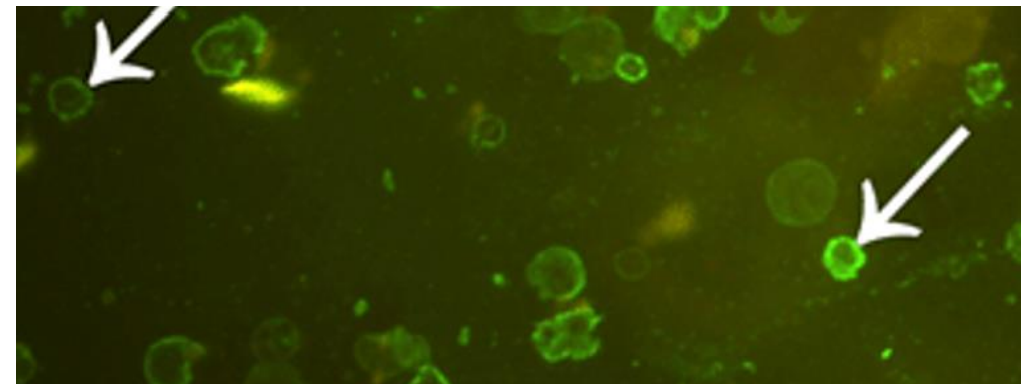
Albumin/globulin ratios in effusion can be useful in the diagnosis of FIP but are not specific for FIP, so must be interpreted in light of all other evidence. Reports of useful cut-off values for A:G ratios in the diagnosis of FIP vary, but in general an A:G ratio of <0.4 makes FIP very likely.



Immunohistochemical Methods to Diagnose Atraumatic Spleen Rupture in Feline Infectious Peritonitis of Tiger (*Panthera tigris*)

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Macrophages and lymphocytes positive for FCoV antibodies (arrows) in pericardial fluid. Direct immunofluorescence test





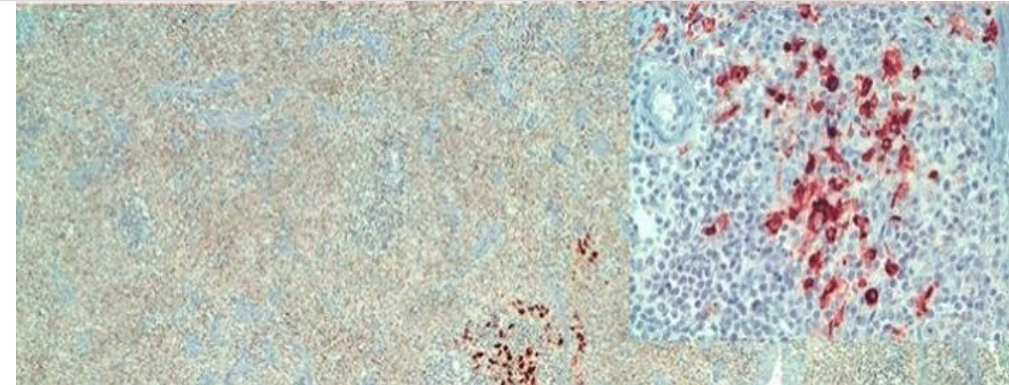
DEFINITIVE DIAGNOSIS OF FIP

Immunohistochemistry

IHC of tissue samples is considered the gold standard for diagnosing FIP

IHC is recommended when histology is consistent with FIP:

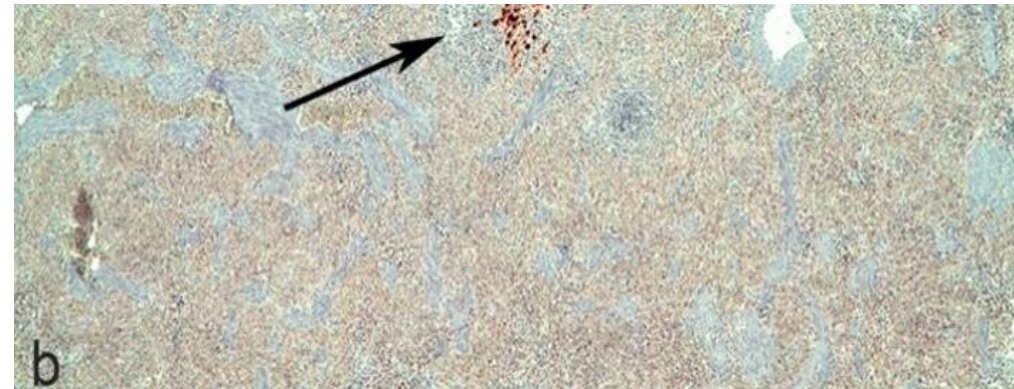
- Sensitivity: 46.2 - 76.9%
- Specificity: 100%



Article

Concordance between Histology, Immunohistochemistry, and RT-PCR in the Diagnosis of Feline Infectious Peritonitis

Angelica Stranieri ^{1,2}, Donatella Scavone ^{1,2}, Saverio Paltrinieri ^{1,2,*}, Alessia Giordano ^{1,2}, Federico Bonsembiante ^{3,4}, Silvia Ferro ³, Maria Elena Gelain ³, Sara Meazzi ^{1,2} and Stefania Lauzi ^{1,2}





DEFINITIVE DIAGNOSIS OF FIP

IDEXX FIP Virus RealPCR™?

Specific PCR Test

= FIP Virus RealPCR™

= Detects Feline Coronavirus 7b gene and may detect mutations M1058L and S1060A of the spike gene.

The detection of these mutations in a feline tissue sample is strongly supportive of FIP in a cat with consistent clinical history / other diagnostic tests supportive of FIP.

Sensitivity is higher in tissues from inflamed organs and lower in organs not histologically involved

Some examples include:

| | Sensitivity | Specificity |
|-------------|---------------|--------------|
| Effusion | 68.6 - 88.9 % | 95.8 – 100 % |
| Whole Blood | 0 – 30 % | 100 % |

i.e. it cannot be used to exclude FIP





DEFINITIVE DIAGNOSIS OF FIP

Signalment



Clinical Signs

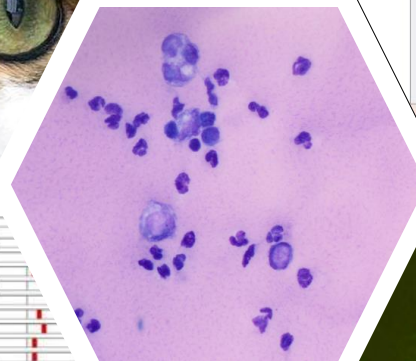
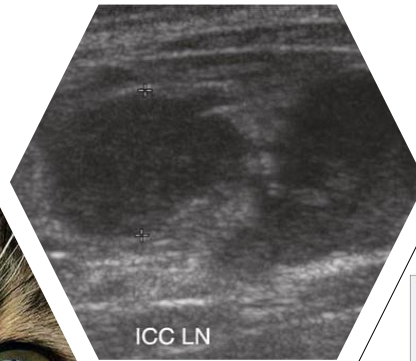
Physical Exam



Blood Findings

| | Result | Reference Range | Low | High |
|------------------------|--------|------------------|------|------|
| GLUCOSE | 5 | 0 - 62 U/L | | |
| ALBUMIN | 45 | 28 - 100 U/L | | |
| BUN | 74 | 5 - 55 U/L | HIGH | |
| CREATININE | 512 | 64 - 440 U/L | HIGH | |
| CHOLESTEROL | 2 | 0 - 6 U/L | | |
| ALB | 2.0 | 2.3 - 3.9 g/dL | LOW | |
| TOTAL PROTEIN | 9.4 | 5.9 - 8.3 g/dL | HIGH | |
| BILIRUBIN | 7.4 | 3.0 - 5.6 mg/dL | HIGH | |
| TOTAL BILIRUBIN | 1.2 | 0.0 - 0.4 mg/dL | HIGH | |
| DIRECT BILIRUBIN | 0.5 | 0.0 - 0.2 mg/dL | HIGH | |
| HEMATOCRIT | 21 | 15 - 34 mg/dL | | |
| HEMATOCRIT (CORRECTED) | 0.8 | 0.8 - 2.3 mg/dL | | |
| CHOLESTEROL | 177 | 82 - 218 mg/dL | | |
| GLUCOSE | 112 | 70 - 150 mg/dL | | |
| UREA NITROGEN | 8.4 | 8.2 - 11.8 mg/dL | | |
| CREATININE | 5.4 | 3.0 - 7.0 mg/dL | | |
| CARBONATE | 19 | 15 - 25 mEq/L | | |
| PH | 7.20 | 7.37 - 7.43 | | |
| PCV | 3.7 | 3.9 - 5.3 mEq/L | LOW | |
| TOTAL SOLIDS | 148 | 147 - 156 mEq/L | | |
| ALB | 0.3 | 0.4 - 0.8 | LOW | |
| TOTAL BILIRUBIN | 0.7 | 0 - 0.3 mg/dL | HIGH | |
| PLATELETS | 40 | | | |

Imaging Findings



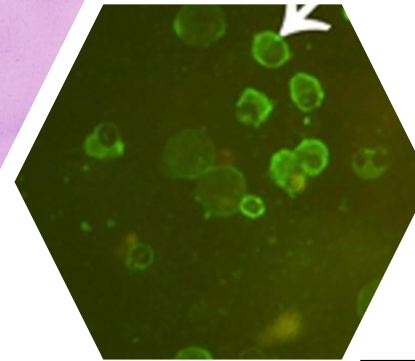
Cytology

FIP RT-PCR

FIP Virus RealPCR™ Test

- On peritoneal, pleural or CSF fluid
- On tissue biopsy or aspirate

Step 4. Confirmatory testing



ICC / IHC

The addition of a positive FIP specific PCR OR ICC / IHC is needed to make a definitive diagnosis





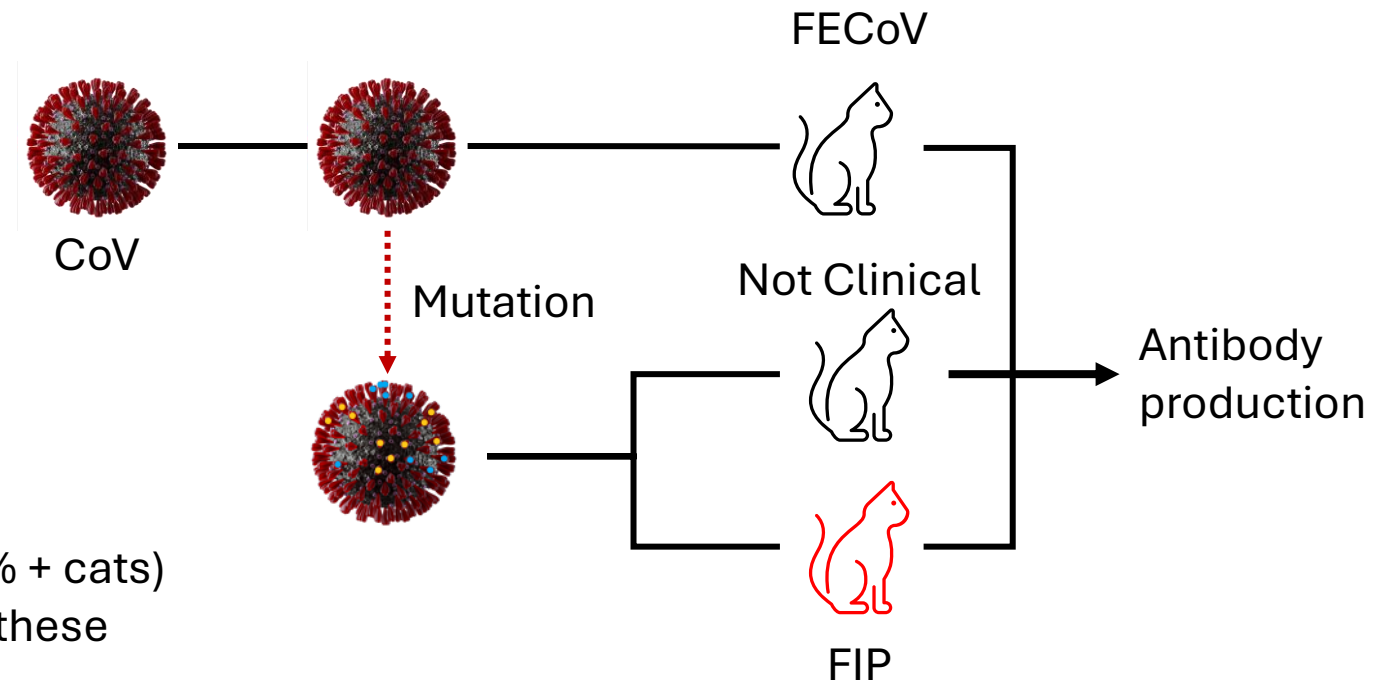
CORONAVIRUS ANTIBODY (AB) TESTING?

The short answer is NO

It's well-accepted that Ab tests cannot differentiate between FECoV and FIPV Abs

Even very high Ab titres in blood are not specific for FIP.

A large proportion of the cat population (80% + cats) have serum **Abs against FCoV**, but most of these cats **never develop FIP**



THE PRESENCE OF ANTIBODIES FOR DIAGNOSING FIP HAS VERY LIMITED SIGNIFICANCE

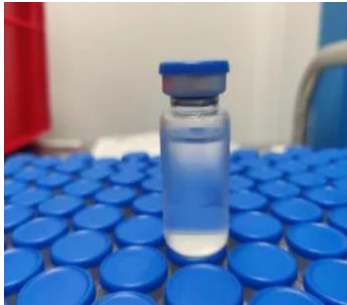


How is FIP Treated?





HOW IS FIP TREATED?



BOVA: Remdesivir for IV or SC injection

Remdesivir is a prodrug (nucleotide prodrug) able to diffuse into cells, where it is converted to GS-441524 monophosphate



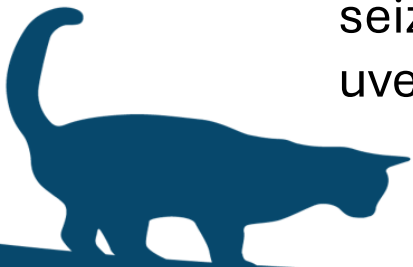
BOVA: Oral GS-441524 tablets

The basics:

- Drainage of fluid (when necessary)
- Reduction of stress
- Treatment of specific comorbidities (i.e. anti-epileptic medication if seizuring, ocular medications if uveitis is present, etc.).

Antiviral drug therapy:

1. Viral Protease Inhibitor such as GC376
2. Nucleoside Analogues (RNA Transcription Inhibitors)
→ GS-441524 or Remdesivir





How is FIP TREATED?

GS-441524 & Remdesivir



Effusive



Ocular



Neurological

An update on treatment of FIP in the UK

Dr. Sam Taylor BVetMed(Hons) CertSAM DipECVIM-CA MANZCVS FRCVS
Prof. Séverine Tasker BVSc BSc DSAM PhD DipECVIM-CA FHEA FRCVS
Prof. Danielle Gunn-Moore BSc(Hon), BVM&S, PhD, MANZCVS, FHEA, FRSB, FRCVS
Dr. Emi Barker BSc BVSc PhD PGCertTLHE DipECVIM-CA MRCVS
Dr. Stephanie Sorrell BVetMed(Hons) MANZCVS DipECVIM-CA MRCVS

Table 1: Summary of dosage recommendations for remdesivir and GS-441524

| Clinical presentation | Remdesivir – by injection | GS-441524 – oral |
|--|---------------------------|---|
| Cats with effusions and without ocular or neurological signs | 10 mg/kg once daily | 10-12 mg/kg once daily |
| No effusion and without ocular or neurological signs | 12 mg/kg once daily | 10-12 mg/kg once daily |
| Ocular signs present (effusive and non-effusive) | 15 mg/kg once daily | 15 mg/kg once daily |
| Neurological signs present (effusive and non-effusive) | 20 mg/kg once daily | 10 mg/kg twice daily (i.e. 20 mg/kg given as a divided dose) |



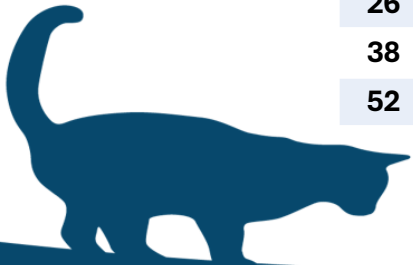


HOW IS FIP TREATED?

GS-441524 & Remdesivir

| Treatment Phase (Weeks 0-12) | | | | | |
|--|--------------|------------|----|----------|--------------------|
| | PEx / Weight | CBC / Chem | UA | Centesis | Retroviral Testing |
| 0 | ✓ | ✓ | ✓ | ✓ * | ✓ |
| 2 | ✓ | | | * | |
| 4 | ✓ | | | * | |
| 6 | ✓ | | | * | |
| 8 | ✓ | | | * | |
| 10 | ✓ | | | * | |
| 12 | ✓ | ✓ | ✓ | * | |
| Monitoring Phase (Weeks 13-52) – Owner / Patient / Vet Dependent | | | | | |
| 14 | ✓ | | | | |
| 18 | ✓ | | | | |
| 22 | ✓ | | | | |
| 26 | ✓ | | | | |
| 38 | ✓ | | | | |
| 52 | ✓ | | | | |

* Centesis to be performed only if necessary



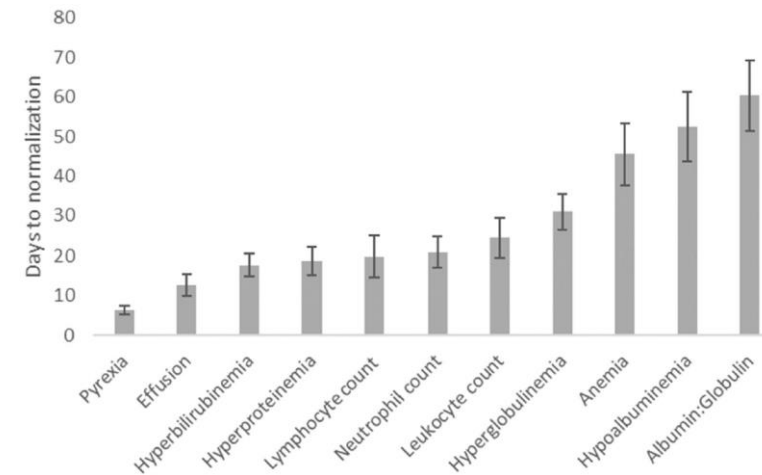
DOI: 10.1111/jvim.16803

STANDARD ARTICLE

Journal of Veterinary Internal Medicine **ACVIM**
Open Access American College of Veterinary Internal Medicine

Outcomes of treatment of cats with feline infectious peritonitis using parenterally administered remdesivir, with or without transition to orally administered GS-441524

Sally J. Coggins¹ | Jacqui M. Norris¹ | Richard Malik^{2,3} | Merran Govendir¹ | Evelyn J. Hall¹ | Benjamin Kimble¹ | Mary F. Thompson¹



Days to normalisation for key clinical and clinicopathologic parameters in 25 cats with FIP that survived to complete 84 days of treatment



ANTIVIRAL RESISTANCE?

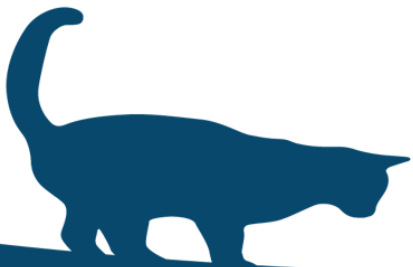


“in the face of cost and emergence of viral drug resistance, the aim should still be to be as confident as possible that a cat is truly suffering from FIP before starting antiviral treatment, and this can only be done by veterinarians”

- Daniela Krentz et al. Viruses. 2021 Nov; 13(11): 2228.
- Curing Cats with Feline Infectious Peritonitis with an Oral Multi-Component Drug Containing GS-441524

Resistance to GS-441524 has been confirmed over the last 3 years (Pedersen NC. 2021)

The rapid mutation of RNA viruses promotes resistance to drugs directly targeting viral proteins.





ANTIVIRAL RESISTANCE?

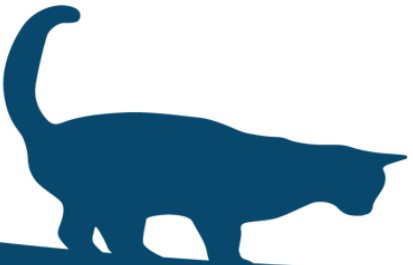


Drug resistance can only be overcome in two manners:

1. By progressively increasing the antiviral dosage to achieve drug levels in body fluids that exceed the level of resistance), or
2. By using another antiviral drug that has a different resistance mechanism, either by itself or in combination.

With the rise of COVID-19, effective anti-viral drugs have only recently become readily available for veterinary use.

Resistance to this is likely to cause FIP mortality to increase, as few other options are available



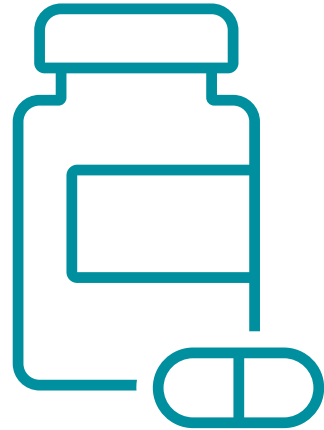
Prognosis





PROGNOSIS

TREATMENT



Non-virus specific medications only
95% mortality within 12 months.

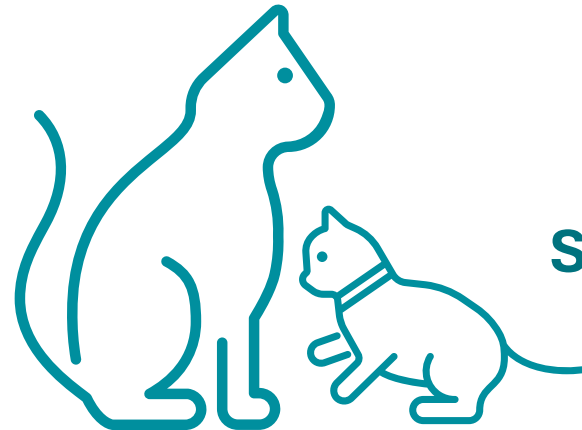
GS-441524 and remdesivir
Potentially curative, with ~ 80% survival within 16 weeks of diagnosis and commencing treatment.

Younger cats

Often more acute and severe disease
Shorted survival times

Older cats

More chronic, less severe
Longer survival times



SIGNALMENT

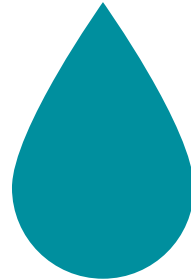




PROGNOSIS



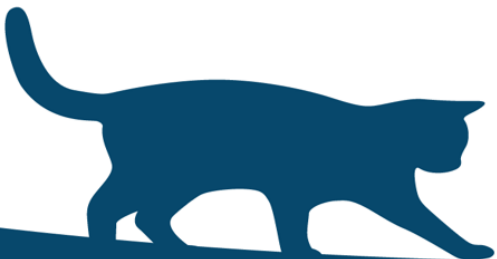
Marked pyrexia, lethargy, inappetence, weight loss, and icterus are indications of a poorer prognosis.



Lymphopenia is often associated with more fulminant disease. Higher counts are associated with more localised and less intense inflammation.



Cats that are still active, eating, and maintaining weight are more likely to manifest lower-grade fever, clearer fluid, and less likely to be icteric.



Prevention





PREVENTION

Controlling
FECoV is
challenging
and largely
impractical

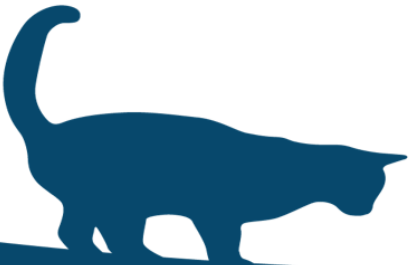
Endemic
circulation in
communally
housed cats

Best prevention methods

1. Eliminate overcrowding
2. Actively manage litter boxes & litter dust
3. Breed a minimum number of litters
4. Don't breed from cats with FIP positive kittens

Widespread prophylactic use of anti-viral medications against FECoV is strongly discouraged

- Increases risk of generating antimicrobial-resistant viruses
- Antiviral therapy only temporarily decreases FECoV shedding





MANY AVAILABLE RESOURCES!!

ABCD FIP: diagnostic approach I

Evidence contributing to being highly suspicious of a diagnosis of feline infectious peritonitis

ABCD TOOL

Clinical examination
Fever (typically 40°C) +++
Mucous membranes: *icterus/jaundice* ++
Pallor +
Abdominal palpation: *Fluid thrill due to ascites* +++
Irregular organomegaly (e.g. kidneys, lymph nodes) +++
Masses (e.g. abdominal lymph nodes, intestinal) ++
Ascitation:
Absence or dullness of heart sounds ++
Heart murmur / arrhythmia –
Absence of lung sounds ++
Increased lung sounds with crackles –
Percussion of chest dull ventrally ++
Tachypnoea or dyspnoea ++
Oscoscopic examination:
Evidence of ear disease (e.g. polyps, otitis externa / media) –
Ocular examination (unilateral or bilateral changes):
Change in iris colour +++
Dysconia/anisocoria +++
Hyphaemia ++
Aqueous or vitreous flare ++
Other signs of uveitis ++
Pervascular cuffing of retinal vessels ++
Nystagmus ++
Retinal detachment +
Neurological examination:
Ataxia +++
Seizures +++
Mental state or behaviour changes +++
Head tilt ++
Priapism ++
Scrotal enlargement ++
Multiple skin nodules or papules +
Body condition score <math>< 5/9</math> ++
Bicavitary effusion ++

Haematology
Mild non-regenerative anaemia ++
Severe non-regenerative anaemia +
Regenerative anaemia –
Microcytosis ++
Lymphopenia (mild ± left shift) ++
Neutrophilia ++
Lymphocytosis –

Key: The + & – symbols indicate how likely or unlikely factors listed are to make a diagnosis of FIP

– slightly less likely
– moderately less likely
– far less likely
– extremely unlikely
+ slightly more likely
+ moderately more likely
+ far more likely
+ extremely likely

Signalment & history
Signalment
<math>< 2</math> years ++++
>5 years –
Male +
Pedigree + (breeds vary geographically)
Dietary history compatible with thiamine deficiency –
History
Weight loss/failure to thrive /stunted growth +++
Swollen abdomen +++
Persistent/fluctuating fever non-responsive to antibiotics +++
Lethargy/dullness ++
Inappetence ++
Dyspnoea ++
Vision or ocular abnormalities incl. iris colour change &/or nystagmus ++
Jaundiced mucous membranes ++
Ataxia/paralysis (para- or tetra-), hyperaesthesia, seizures ++
Sibling (or in-contact) with FIP ++
Multi-cat household +++
Pale mucous membranes +
Diarrhoea, vomiting &/or constipation +
Recent stress (e.g. vaccination, rehoming, neutering) ++
Outdoor only/feral cat –
History of fighting –

Serum biochemistry
Hyperbilirubinaemia +++
Hyperglobulinaemia +++
Hyperproteinemia (or total solids) ++
Hypoalbuminaemia +
Albumin to globulin [A/G] ratio
A/G ratio <math>< 0.4</math> +
A/G ratio > 0.6 –
Alpha-1-acid glycoprotein, if available:
>1.5 mg/mL ++
>3.0 mg/mL +++
<math>< 1.5</math> mg/mL –
Serum protein electrophoresis, if performed:
Polyclonal gammopathy +
Marked elevation in ALT & ALP –
Only mild or moderate elevation in ALT & ALP with hyperbilirubinaemia +
FCoV antibody test with high titre +
FCoV antibody test negative –

Locate & analyse effusion if present*
Locate any effusion
Ultrasonography is most useful to locate/direct fluid sampling
Bicavitary effusion +++
Abdominal ultrasonography:
Peritoneal (or retroperitoneal) fluid +++
Thoracic ultrasonography:
Pleural (or pericardial) fluid ++
Thoracic radiography:
Pleural fluid ++

Haematology
Cytology:
Non-degenerate neutrophils & macrophages +++
Non-degenerate neutrophils, macrophages & a few lymphocytes +++
Toxic neutrophils ± bacteria visible –
Neoplastic cells –
Marked lymphocytosis –
Marked neutrophilia –

Effusion cytology & biochemistry consistent with FIP? Go to diagram 1

For differential diagnoses of FIP, see box 5

*** Absence of effusion & presence of nonspecific clinical signs? Go to diagram 2**
Neurological findings consistent with FIP? Go to diagram 3
Ocular findings consistent with FIP? Go to diagram 4

Modified from: Barker E & Tasker S. (2020). Advances in Molecular Diagnostics and Treatment of Feline Infectious Peritonitis. *Advances in Small Animal Care* 1: 161–188

ABCD FIP: diagnostic approach IIa

Looking for evidence that confirms FIP as a diagnosis following a high suspicion:

ABCD TOOL

1 Effusion sample cytology & biochemistry consistent with FIP
Effusion sample analysis
FCoV RT-PCR &/or immunocytochemistry for FCoV antigen
if all suspicious of FIP, continue monitoring as abnormalities can develop over time, which can then be sampled for diagnosis by either FNA, touch or full biopsy (e.g. immunocytochemistry for FCoV antigen)

2 Absence of an effusion & presence of nonspecific clinical signs: perform diagnostic imaging*
FNA sample of any abnormal organ/tissue
Big (measurable) nodules with consistent cytology (neutrophils or macrophages)
FCoV RT-PCR &/or immunocytochemistry for FCoV antigen
if all suspicious of FIP, continue monitoring as abnormalities can develop over time, which can then be sampled for diagnosis by either FNA, touch or full biopsy (e.g. immunocytochemistry for FCoV antigen)

3 CSF sample analysis: FCoV RT-PCR &/or immunocytochemistry for FCoV antigen
if all suspicious of FIP, continue monitoring as abnormalities can develop over time, which can then be sampled for diagnosis by either FNA, touch or full biopsy (e.g. immunocytochemistry for FCoV antigen)

4 Aqueous humour cytology consistent with FIP* (neutrophils or macrophages)
Aqueous humour sample analysis:
FCoV RT-PCR &/or immunocytochemistry for FCoV antigen
if all suspicious of FIP, continue monitoring as abnormalities can develop over time, which can then be sampled for diagnosis by either FNA, touch or full biopsy (e.g. immunocytochemistry for FCoV antigen)

5 For differential diagnoses of FIP, see box 5

ABCD FIP: diagnostic approach IIb

Looking for evidence that confirms FIP as a diagnosis following a high suspicion:

ABCD TOOL

3 CSF sample analysis: FCoV RT-PCR &/or immunocytochemistry for FCoV antigen
if all suspicious of FIP, continue monitoring as abnormalities can develop over time, which can then be sampled for diagnosis by either FNA, touch or full biopsy (e.g. immunocytochemistry for FCoV antigen)

4 Aqueous humour cytology consistent with FIP* (neutrophils or macrophages)
Aqueous humour sample analysis:
FCoV RT-PCR &/or immunocytochemistry for FCoV antigen
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5 For differential diagnoses of FIP, see box 5

If you found this ABCD information valuable, please tell a colleague. To download the ABCD tools, fact sheets, or the full disease guidelines, please visit our website: www.abcdcatsvet.org
The ABCD Europe is an independent association of experts in feline health. This tool was supported by Boehringer Ingelheim (founding sponsor), Virbac, Ilexac and MSD, September 2023.

ABCD – European Advisory Board of Cat Diseases



A close-up, profile view of a grey and white cat's face. The cat has striking yellow eyes and is looking towards the right. The background is a soft, out-of-focus light blue and green. The text "Thank you for your time" is overlaid in the upper right quadrant in a white, bold, sans-serif font.

**Thank you for
your time**

**Tiarni Johnston
BVSc (Hons) MANZCVS (SAM)
Resident in Internal Medicine**

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