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1 **Twelve autologous blood transfusions in eight cats with haemoperitoneum**

2

3 **Abstract**

4

5 **Objective:** The objectives of this study were to describe the clinical use and
6 outcome of autologous transfusions in cats with intracavitary haemorrhage

7 **Methods:** A retrospective descriptive study was performed. Computerised
8 medical records of a single referral centre were searched for cats receiving an
9 autotransfusion. Medical records were evaluated for underlying disease process,
10 autotransfusion technique, autotransfusion volume, time period over which the
11 autotransfusion was given, packed cell volume (PCV) pre and post
12 autotransfusion, percentage rise in PCV, use of other blood products and any
13 complications of the procedure. Survival to discharge and survival at 2 months
14 was documented.

15 **Results:** Between July 2012 and March 2018 a total of 12 autotransfusions were
16 performed in 8 cats. All patients were diagnosed with haemoperitoneum. Four of
17 the 8 cats were diagnosed with abdominal neoplasia, 3 had post-operative
18 haemorrhage and 1 had a traumatic haemoperitonuem. Three cats received more
19 than one autotransfusion. Blood was collected using a 23g butterfly catheter and
20 20ml syringe in 7/12 collections, a 23g needle and 20ml syringe in 2/12
21 collections and directly into syringes from the open abdomen at the time of
22 surgery in 3/12 collections. A median volume of 50ml (range 25-80ml) was
23 collected and administered, meaning a median volume of 16.5ml/kg (range 9-
24 26ml/kg) was administered. The autologous transfusions were given over a
25 median of 3 hours (0.25-6 hours). Five cats were given another blood product
26 alongside the autotransfusion. Median percentage PCV increase was 5% (range
27 1-7%). Anti coagulant was used in 5/12 autotransfusions. No clinically relevant
28 adverse effects were reported. Six of the 8 cats survived to discharge. Two month
29 survival was 60% (3/5).

30 **Conclusions and relevance:** Autologous transfusion appears to be a safe and
31 effective technique for stabilising cats with haemoperitoneum. This technique
32 allows rapid and cheap provision of blood and avoids the need for an allogenic
33 blood donor.

34

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46

47

48 **Twelve autologous blood transfusion in eight cats with haemoperitoneum**

49

50 **Introduction**

51 The transfusion of blood products to anaemic patients is an important part of
52 critical care. However, access to feline blood products can be limited due to
53 technical difficulties in collecting and storing feline blood products and
54 difficulties in recruiting feline blood donors. ¹ Both haemoglobin based oxygen
55 carriers (HBOCs) and xenotransfusion with canine blood products have been used
56 as alternative strategies for the anaemic cat. ^{2,3,4} However, HBOCs have well
57 documented adverse effects and transfused canine red blood cells have a short
58 life span a result of intravascular haemolysis. ^{2,5} An alternative method to
59 allogenic transfusion, that is well described in the human literature, is
60 autotransfusion. ⁶ Autotransfusion has been reported in dogs with intracavitary
61 haemorrhage in the veterinary literature, but there are no clinical reports in cats.
62 ^{7,8,9,10,11,12} In these canine studies minor, non-clinically significant adverse effects
63 were reported and autotransfusion appeared to be a successful management
64 option. This study aimed to investigate the frequency and efficacy of feline
65 autotransfusion in a referral hospital setting, as well as describing the reasons
66 for performance of autotransfusion and the methods used.

67

68 **Materials and methods**

69

70 **Inclusion criteria**

71 The electronic clinical and surgical records from the Queen Mother Hospital for
72 Animals (Hatfield, UK). were searched for cats that were administered an
73 autotransfusion between July 2012 and March 2018.

74

75 **Retrieved data**

76 The following data was extracted from the clinical records; signalment,
77 underlying disease, technique of blood collection, volume of blood collected, use
78 of anticoagulant, volume of autologous blood transfused, transfusion time
79 period, pre and post transfusion PCV, serum calcium, prothrombin time and
80 partial thromboplastin time post transfusion and administration of other blood
81 products. Survival to discharge and 2 month survival were also documented.

82

83 **Results**

84

85 A total of 8 cats had at least one autotransfusion during the time period. Six
86 were female (5 neutered) and 2 were male (1 neutered). Five were Domestic
87 short hairs and 3 were pure breeds (British short hair, Ragdoll and Bengal). The
88 median weight of the cats was 3.67Kg (range 1.38-5.5Kg). All cats were blood
89 typed. Six cats were blood type A and 2 cats were blood type B.

90

91 Four of the 8 cats had spontaneous hemoperitoneum secondary to abdominal
92 neoplasia (2 cats had splenic haemangiosarcoma, 1 cat had both splenic and liver
93 haemangiosarcoma and one cat had liver and splenic lesions consistent with
94 neoplasia on ultrasound but histological diagnosis was not made). Three of the 8
95 cats required an autotransfusion for management of post-operative

96 haemorrhage (the surgical procedures were routine ovariohysterectomy
97 performed at the primary care vets in two cats, and extra-hepatic shunt ligation
98 and liver biopsy in the other cat). One cat presented with a traumatic
99 haemoperitoneum. Six out of 8 cats required surgery for management of their
100 condition.

101

102 A total of 12 autotransfusions were performed over the study period. Three cats
103 had an autologous transfusion performed on more than one occasion. Case 1, a
104 cat with a traumatic haemoperitoneum, required autotransfusion on
105 presentation and 12 hours later due to continuing haemorrhage. Surgical
106 exploration revealed a splenic fracture with bleeding splenic artery. An
107 autotransfusion was performed on case 3 prior to surgery for removal of a
108 poorly differentiating splenic haemangiosarcoma and it required repeat
109 autotransfusion 10 days post discharge to due recurrence of the
110 haemoperitonuem. Case 5 received an autotransfusion during cardiopulmonary
111 arrest suspected to be due to haemorrhage post surgery for extra-hepatic
112 portosystemic shunt ligation and liver biopsy. Autotransfusion was performed
113 again at the time of revision surgery (0.5 hours later) and also in the post-
114 operative period (2 hours later).

115

116 Autotransfusion was performed in all cats to treat their anaemia and
117 hypovolaemia. Three of the 12 autotransfusions were performed intra-
118 operatively, 1/12 was performed post-operatively and 2/12 were performed
119 peri-cardiopulmonary arrest.

120

121 Out of the total 12 autotransfusions performed, blood was collected using a 23g
122 butterfly catheter and 20ml syringe in 7 collections, a 23g needle, three-way tap
123 and 20ml syringe in 2 collections and directly into syringes from the open
124 abdomen at the time of surgery in 3 collections. Ultrasound guided sampling was
125 performed in all cases except collection at the time of surgery.

126

127 Anti-coagulant acid citrate dextrose (ACD-A, USA) was used in 5/12 of the
128 autotransfusions performed with 0.14ml of ACD used per 1ml of blood collected
129 as described in previous studies.¹³ In all cases the collected blood was transfused
130 through an 18µm blood filter (Utah Medical Products, USA). A median volume of
131 50ml (range 25-80ml) was collected and administered, equivalent to median
132 volume of 16.5ml/kg (range 9-26ml/kg) over a median of 3 hours (range 0.25-6
133 hours, the time over which the autotransfusion was administered was not
134 recorded in one case). Three autotransfusions were given in one hour or less at a
135 rate from 0.28ml/kg/min-1.2ml/kg/min.

136

137 The median PCV pre-autotransfusion was 12% (range 7-20%, n = 11). Post
138 autotransfusion, the median PCV was 18% (range 9.5-23%, n = 11) with the
139 median percentage PCV increase being 5% (range 1-7%, n =10).

140

141

142 During the administration of the autotransfusions there were no documented
143 report of urticaria, erythema, increased rectal temperature or other signs
144 consistent with transfusion reaction. Post-transfusion ionised calcium levels
145 were available after 7/12 autotransfusions. The median ionised calcium value

146 was 1.22mmol/L (range 0.92-1.3mmol/L). Total calcium was measured in 1
147 patient and this was 2.03mmol/L (RI 2.07-2.8mmol/L). Out of these 8 patients 2
148 were documented as having a mild hypocalcaemia of which one received
149 anticoagulant. No patient showed clinical signs of hypocalcaemia.

150

151 Five of the 8 cats received other blood products. Case 2 and case 8 who
152 presented with haemoperitonuem post routine ovariohysterectomy received
153 both packed red blood cells and type specific fresh frozen plasma. Case 8
154 received type specific feline packed red blood cells and case 2 received canine
155 packed red blood cells due to the lack of availability of feline blood at the time of
156 admission. Case 5 received feline whole blood and oxyglobin and case 4 and 7
157 received feline packed red blood cells (Table 1).

158

159 Coagulation tests were assessed in three cats prior to the first autotransfusion
160 and were found to be within normal limits. Two cats had prothrombin time (PT)
161 and activated partial thromboplastin time (aPTT) measured post
162 autotransfusion; one had had mild prolongation of aPTT and one had moderately
163 prolonged PT and aPTT as well as a severe thrombocytopaenia of $40 \times 10^9/l$ (RI
164 $200-800 \times 10^9/L$). This cat (case 2) had received canine packed red blood cells
165 and autologous transfusion in less than 2 hours. A total of 10ml/kg fresh frozen
166 plasma transfusion was given for management of the coagulopathy. Four hours
167 post all transfusions the patient was found to have an increased respiratory
168 effort and documented pleural effusion, suspected to the result of fluid overload.
169 The patient was treated with oxygen and 2mg/kg frusemide (Diamzon, MSD
170 Animal Health).

171

172 Gross haemolysis was detected in one cat (case 3) post autotransfusion on
173 examination of serum, but this had also been present prior to autotransfusion.

174 This patient's PCV increased by 2 and 2.5% after each autotransfusion.

175

176 Three cats had cytology performed on the abdominal fluid and 2 cats had culture
177 of the abdominal fluid used for autotransfusion. None of these cases had
178 cytological evidence of bacteria. One cat out of the 2 (case 6) that had culture of
179 the abdominal fluid cultured positive for *Enterococcus faecalis*. This case was
180 given an autologous transfusion after respiratory arresting and was euthanased
181 due to progressive neurological deterioration.

182

183 **Outcome**

184 Six of the 8 cats survived to discharge. No delayed adverse reactions to the
185 autotransfusions were reported in any patient. Both of the patients that died in
186 hospital were given an autotransfusion peri-cardiopulmonary arrest. Case 5
187 arrested post operatively after extra-hepatic portosystemic shunt ligation and
188 hepatic biopsy. This patient regained spontaneous circulation and had repeat
189 surgery to performed isolate the bleeding vessel. The patient was euthanased on
190 recovery from general anaesthesia due to severe hypoxaemia, despite further
191 autotransfusion, whole blood, crystalloid and colloid and vasopressor therapy.
192 Case 6 neurologically deteriorated and was euthanased post respiratory arrest.

193

194 Two-month survival was 60% (3/5). Two patients (cases 3 and 4) were
195 diagnosed with splenic and liver haemangiosarcoma and were euthanased 4 and

196 6 weeks post discharge respectively. Both patients re-presented collapsed and
197 pale, one with a recorded PCV of 9%. This latter patient was presumed to have
198 had a repeat abdominal haemorrhage. The other case (case 7) diagnosed with
199 splenic haemangiosarcoma was lost to follow up. Case 1 with traumatic
200 hemoperitoneum and case 2 and case 8 with haemoperitoneum post
201 ovariohysterectomy are reported to be well on follow up.

202

203

204 **Discussion**

205

206 The aim of this case series was to examine the use of autotransfusion in feline
207 patients in a referral hospital setting. We report eight cats, which had an
208 autotransfusion to aid treatment of their anaemia. Given the high caseload of
209 the hospital, this is not a frequently performed procedure, probably helping to
210 explain the lack of literature on the use of autotransfusion in cats. A recent
211 survey of canine and feline transfusion practice found that autotransfusion is
212 performed in 36% of both primary care and tertiary referral centres in the USA.

213 13

214 Three main autotransfusion techniques have been described in man; pre-
215 operative autologous donation (PAD) whereby blood is collected in advance of
216 an elective procedure, stored in the blood bank and transfused back to the
217 patient when required, acute normovolaemic haemodilution where blood is
218 collected immediately prior to surgery and blood volume restored by crystalloid
219 or colloid, and cell salvage in which blood is collected from suction, surgical

220 drains, or both and re-transfused back to the patient after filtration or washing.⁶

221 There is one experimental report of autologous transfusion in cats and one
222 clinical report of PAD in cats performed prior to planned craniotomy surgery.^{15,}

223 ¹⁶ There are various reports of canine cell salvage in the veterinary literature.

224 8,9,10,11,12

225

226 Autotransfusion can be considered an underused method in cats as it has several
227 advantages when compared to the use of allogenic blood products. The blood is
228 readily available and is cheaper than allogenic blood products as there is no need
229 for blood typing or cross matching. This is particularly useful outside large
230 referral hospitals in the UK as there is no commercial feline blood bank and
231 access to blood donors, particularly type B and AB cats can be limited.

232 Autotransfusion has the proposed advantage of reducing the risk of transmission
233 of disease or isoimmunisation associated with allogenic blood transfusion. A
234 meta-analysis in man found that red cell salvage reduced exposure to allogenic
235 blood by 40%.¹⁶ In this case series 40% of cats did not require allogenic blood
236 products, compared to 30% dogs undergoing autotransfusion.¹⁰

237

238 Cell salvage in man has been predominantly used intra-operatively in
239 cardiothoracic, vascular, orthopaedic, neurological and transplantation surgery
240 and there are rare reports of its use in the emergency department.^{6,17} In dogs
241 autotransfusion has been used primarily for resuscitation in emergencies, the
242 management intra-operative haemorrhage and coagulopathy, post operative
243 haemorrhage and bleeding secondary to neoplasia where surgical intervention

244 may or may not be required. ^{8,10,12} In this case series, autotransfusion was a key
245 part of stabilisation in all 8 of the cats as well as providing intra-operative
246 support and included similar causes as the aforementioned studies. Surgery was
247 performed as well as autotransfusion in 66.7% (8/12) autotransfusion events,
248 similar to the number requiring surgery in dogs undergoing an autotransfusion.

249 ¹⁰

250

251 Techniques for red cell salvage in man and dogs include direct collection from
252 the abdomen using a syringe or suction device and the use of a cell saver device
253 whereby shed blood is collected, anticoagulated and washed or filtered prior to
254 re-transfusion via a filter. ^{6,8,9,11} A cell salvage device has the advantage of
255 washing and filtering the blood and thus removing potentially antigenic cells
256 such as leukocytes, neoplastic cells. ¹⁸ However, most cell salvage systems
257 require a predetermined volume of erythrocytes prior to washing, making it less
258 suitable for most cats where collected blood volumes are usually small. The
259 techniques described for autotransfusion in the cats of this case series were
260 percutaneous collection by ultrasound guidance using a butterfly catheter
261 connected to 20ml syringe or direct collection via a 20ml syringe at the time of
262 surgery, similar to that reported in the case series of 25 dogs. ¹⁰

263

264 In 5 out of the 12 autotransfusion cases blood was collected into acid citrate
265 (ACD-A). The use of anticoagulant in autotransfusion is controversial. Some
266 literature suggests that blood in contact with peritoneal surface greater than one
267 hour become defibrinated and thus systemic anti-coagulant is unnecessary and
268 the citrate itself may lead to hypocalcaemia. ¹⁸ In 2/8 autotransfusion events

269 where ionised or total calcium was available post transfusion there was a
270 documented mild non-clinically significant hypocalcaemia. Acid citrate was used
271 only in one of these cases. Hypocalcaemia has been reported in dogs undergoing
272 autotransfusion via cell saver device and direct collection.^{10,11} In one study of
273 autotransfusion in dogs, 50% of the cases were administered blood with
274 anticoagulant and 50% without and there was no association seen between the
275 use of anticoagulant and survival.¹⁰ Further studies are required to investigate
276 the clinical relevance of anti coagulant use in autotransfusion in cats.

277

278 The use of a blood filter is recommended for re-delivery of blood in attempt to
279 remove microaggregates that could promote an inflammatory reaction. Platelets
280 and platelet products have been found to incite an inflammatory reaction, which
281 can lead to the development cutaneous oedema and acute respiratory distress
282 syndrome.¹⁹ The filter size of 18 micron used in the cats of this case series has a
283 high microaggregatory retention preventing platelet and leukocyte passage.
284 However, this size filter will not filter serotonin, histamine or catecholamine,
285 which are reported to lead to an increase risk of system inflammatory response.
286 ²⁰ No patient in this case series showed any clinical signs consistent with an
287 inflammatory response post transfusion.

288

289 Each patient, where recorded, received between 9-26ml/kg of autologous
290 blood during each transfusion. Two cats cases received in excess of 30ml/kg
291 total blood product in 4-6 hours and thus by definition underwent a massive
292 transfusion.²⁰ The one patient who received a massive transfusion, and

293 survived, was found to have prolonged PT and APTT and severe
294 thrombocytopenia post transfusion requiring fresh frozen plasma therapy.
295 Autotransfusions have been previously documented to cause consumptive
296 coagulopathy; PT and APTT were prolonged post transfusion in 80% of cases of
297 canine autotransfusions where post transfusion PT and APTT were measured
298 in one study.¹⁰ This hypocoagulability is thought to occur as a result of
299 widespread activation of coagulation system and secondary fibrinolysis when
300 the blood is re-infused.²¹ The cat in this case series that had a prolonged PT and
301 APTT post transfusion received a large volume of crystalloid, massive
302 transfusion of canine packed red blood cells and autologous blood. It is
303 therefore difficult to determine the contribution of the autotransfusion to this
304 coagulopathy. Only one other patient, diagnosed with a traumatic
305 haemoperitoneum had coagulation values measured post the transfusion and
306 this revealed a mild coagulopathy, which could be the result of continual
307 bleeding or the effect of the autotransfusion, or a combination of both. Ideally
308 post transfusion platelet count and clotting times should be assessed to
309 monitor for development of a consumptive coagulopathy.

310

311 Other reported complications of autotransfusion include haemolysis secondary
312 to prolonged exposure to serosal membrane and mechanical injury during
313 collection and re-infusion.^{10, 22, 23} Haemolysis results in the release free
314 haemoglobin that can lead to acute kidney injury. To minimise the risk of
315 mechanical injury to the red blood cells aspiration was performed gently using
316 low suction pressure to minimise cell damage during the retrieval. One cat,

317 diagnosed with a haemangiosarcoma , was reported to have haemolysed serum
318 post autotransfusion, compared to 5/19 (26%) of dogs in a previous study. ¹⁰
319 This patient was also shown to have haemolysed serum pre transfusion and no
320 evidence of worsening post transfusion suggesting it was likely part of the
321 patients disease state. This patient's PCV showed a mild increase in (PCV
322 increase 2-2.5%) post the transfusions, which could have been the result of
323 ongoing haemolysis. Larger studies of feline autotransfusions are required to
324 assess the true prevalence and consequence of haemolysis in these cases.

325

326 One patient suffered from suspected transfusion associated circulatory overload
327 (TACO). This patient had received massive transfusion of canine packed red
328 blood cells and autologous blood products alongside crystalloid therapy and
329 fresh frozen plasma. It is therefore likely it was due to the volume of product
330 versus the type of transfusion. This patient responded well to therapy and went
331 on to make a complete recovery.

332

333 Reported contraindications for autotransfusion in man are surgeries for
334 malignancy, bacterial contamination and contamination of the blood with
335 products that can cause haemolysis such as hypotonic fluids. ⁶ The use of
336 autotransfusion for management of haemorrhage secondary to neoplasia is
337 controversial. It is unclear how well malignant cells are removed by filtration
338 and it has been suggested that autotransfusion can contribute to metastatic
339 spread of the tumour. ²⁴ However, autotransfusion has been described in dogs
340 with haemoperitoneum secondary to neoplasia with no reported complications
341 and studies in man have not shown an increased metastatic rate when auto

342 transfusions have been performed in patients with neoplasia.^{8, 10, 25} In this study
343 50% of patients (4/8) had an autotransfusion due to a ruptured neoplasm, of
344 which 3/4 died within 6 weeks of the autotransfusion. These patients likely
345 already had metastatic disease so we cannot elucidate if the transfusion
346 contributed to disease progression. In this case transfusion itself was life saving
347 treatment and prevented the use of feline blood products, a scarce resource, in a
348 terminal patient.

349

350 In one cat the autotransfusion may have involved infusion of blood contaminated
351 with bacteria. Microbiological culture was performed on the abdominal fluid of 2
352 cats and in 1 case this led to a positive culture for *Enterococcus faecalis*. Bacterial
353 growth of salvaged blood has not previously been reported in the veterinary
354 literature but has been reported in up to 12.7% of blood salvaged in humans.²⁶
355 Patients in this study were followed up for 2 months post autotransfusion and no
356 statistically significant correlation between bacteriologic results of
357 autotransfused blood and infectious complications could be found. The cat with
358 the positive culture in this case series was euthanased shortly after its
359 autotransfusion and therefore it was not possible to determine its clinical
360 significance.

361

362 Two-month survival was 75% for cats available for follow up in this study. In
363 the cats that died the cause of death was euthanasia due to underlying disease
364 and continued haemorrhage, similar to that reported in dogs.¹⁰ This case series

365 supports other studies in man and veterinary species that autotransfusion does
366 not appear to adversely affect mortality or lead to significant complications.^{10,16}

367

368 This case series describes the successful use of a simple cost effective
369 autotransfusion technique using 23g needle or butterfly catheter, 20ml syringe
370 and a blood filter to manage life threatening abdominal haemorrhage and to
371 provide intravascular support under general anaesthesia. This technique is
372 cheap and requires minimal equipment with no clinically significant adverse
373 effects and should be considered in unstable cats with a confirmed non-septic
374 haemoperitoneum. Monitoring for post transfusion haemolysis, coagulopathy
375 and hypocalcaemia are recommended post transfusion.

376

377 In conclusion autologous transfusion appears to be a safe and effective technique
378 for stabilising cats with haemoperitoneum. This technique allowed rapid and
379 cheap provision of blood and avoids the need for an allogenic donor.

380

381

382 **Statement of conflict of interest**

383 The authors received no financial support for the research, authorship, and/or
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385

386

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