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# Comparison of success rate and time to obtain venous cannulation by cutdown technique at 3 locations using canine cadavers

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1 Comparison of success rate and time to obtain venous cannulation by cutdown technique at three  
2 locations using canine cadavers

3  
4 Abstract

5 **Objective** – To compare the success rates and time taken to cannulate the jugular, cephalic and lateral  
6 saphenous veins using a cutdown technique by personnel with four different levels of experience.

7 **Design** – Prospective study.

8 **Setting** – Veterinary university teaching hospital.

9 **Animals** – Eighteen canine cadavers.

10 **Interventions** – Recently euthanized canine patients that were donated to the hospital for research  
11 purposes between October 2019 and March 2020 were enrolled. Four groups of personnel participated  
12 in the study to give four varying levels of experience; eight final year veterinary students, two  
13 registered veterinary nurses, one emergency and critical care intern and one ACVECC diplomate.  
14 Each cannula placer had 5 minutes to attempt cannulation by venous cutdown at each site. Time to  
15 venous cannulation was compared for each site and group and complications encountered during each  
16 attempt recorded.

17 **Measurements and Main Results** – The overall success rate for cannulation of the jugular, cephalic  
18 and lateral saphenous veins were 81%, 84% and 87%, respectively. The median venous cutdown  
19 times for all personnel were: jugular vein 119 seconds (range 51-280 s), cephalic vein 82 seconds  
20 (range 39-291 s) and lateral saphenous vein 110 seconds (range 41-294 s). There was no difference in  
21 time to venous cannulation between veins. When comparing personnel at the three cannulation sites,  
22 the ACVECC diplomate was faster than the registered veterinary nurses and students (P=0.042 and  
23 0.048 respectively). No differences were found between any other groups. Complications encountered  
24 often related to cadaver factors such as hematoma from ante-mortem venipuncture.

25 **Conclusions** - All groups were able to perform venous cutdown at each site with good overall success  
26 even without prior experience of the technique. Venous cannulation by cutdown technique of the  
27 jugular, cephalic or lateral saphenous veins may be considered in an emergency setting by personnel  
28 of various skill levels.

29

30 Keywords: dog, emergency vascular access, resuscitation

31

32 Abbreviations

33 CPA – cardiopulmonary arrest

34 CPR – cardiopulmonary resuscitation

35 DACVECC – Diplomate of the American College of Veterinary Emergency and Critical Care

36 IO - intraosseous

37 IV – intravenous

38 RVN – registered veterinary nurse

39 VC – venous cannulation

## 40 **Introduction**

41           Vascular access is crucial in the emergent and critical patient to enable institution of  
42 appropriate stabilization measures such as intravenous fluid therapy and drug administration.  
43 Percutaneous venous cannulation (VC) can be challenging in patients with poor cardiac output, low  
44 circulating intravascular volume culminating in cardiovascular collapse or in patients which have  
45 undergone cardiopulmonary arrest (CPA) requiring cardiopulmonary resuscitation (CPR) measures.  
46 Repeated attempts of percutaneous VC in these patients can be time consuming and may not prove  
47 successful, thereby negatively affecting patient outcomes.

48

49           If percutaneous peripheral cannulation attempts are unsuccessful and patient stability hinges  
50 on gaining vascular access, VC by cutdown technique may be considered.<sup>1</sup> This emergency technique  
51 involves creation of an incision slightly lateral or medial to the anatomical location of the vein to  
52 allow for vessel visualization and ensure cannulation on the first attempt.<sup>2</sup> This technique may be used  
53 for peripheral (e.g. cephalic, lateral saphenous) or central (e.g. jugular) veins and is similar for both.<sup>2</sup>  
54 Venous cannulation by performing a venous cutdown may be a more rapid technique to obtain venous  
55 access than the more familiar percutaneous method in these difficult circumstances.

56

57           Cannulation of the jugular vein by cutdown technique has previously been documented to be  
58 achieved with an overall success rate of 87.5% in canine cadavers by individuals with varying  
59 experience levels.<sup>3</sup> The median time to cannulation by all individuals in this study was 217.3  
60 seconds.<sup>3</sup> To the authors' knowledge, to date no studies have investigated either the success rate or  
61 time to VC by use of a cutdown technique at other sites in canine patients. If VC by cutdown  
62 technique is required in an emergency, it is crucial for the clinician to know which vein can be most  
63 readily cannulated. The primary aims of this study were to compare the success rates of VC and time  
64 taken to obtain venous access by cutdown technique of the jugular, cephalic and lateral saphenous  
65 veins in canine cadavers. The secondary aims were to compare the success rates of VC and the time  
66 taken to complete the task by personnel with varying levels of clinical experience. We hypothesized  
67 that venous cannulation by cutdown technique of the jugular, cephalic and lateral saphenous vein

68 would be readily achieved by personnel with different clinical experience levels and that time to  
69 cannulation of the lateral saphenous vein would be shorter compared to the cephalic or jugular vein.  
70

71 **Materials and methods**

72 Full ethical approval from the institution's ethical review committee was obtained prior to  
73 study enrollment. Following euthanasia, all canine cadavers donated with full owner consent for  
74 teaching and research purposes at the small animal teaching hospital between October 2019 and  
75 March 2020 were considered for study inclusion. Exclusion criteria included chondrodystrophic  
76 breeds, obesity (assessed as having a body condition score of 9 out of 9) or trauma to the neck or legs  
77 that would hinder the ability to perform venous cannulation. Following inclusion, any previously  
78 placed intravenous cannulas were removed.

79

80 ***Participants***

81 Differing levels of clinical experience were represented by including four different groups of  
82 cannula placers; one Diplomate of the American College of Veterinary Emergency and Critical Care  
83 (DACVECC), one emergency and critical care (ECC) specialty intern, two registered and experienced  
84 ECC veterinary nurses (RVN) with > 5 years of clinical experience and eight final year veterinary  
85 students. No individuals within the RVN or student group had any prior experience of performing  
86 cannulations by venous cutdown. The intern had performed venous cutdown in a cephalic vein on one  
87 occasion prior to the study and was competent placing central venous catheters. The DACVECC had  
88 ample experience of performing a venous cutdown at each site. Each category of cannula placer  
89 (DACVECC, intern, RVN, student) attempted cannulation by cutdown technique at each site 8 times.  
90 The final year veterinary student category was represented by 8 different students who each  
91 participated in the study on one occasion and the two nurses enrolled in this study performed  
92 cannulation by cutdown technique at each site a total of 8 times between them. Eight veterinary  
93 students were included to reflect an inexperienced veterinary surgeon attempting this technique for  
94 the first time. Two RVN, working different shift patterns, were included to increase the likelihood of  
95 RVN availability corresponding with cadaver availability. Participation in the study was on a  
96 voluntary basis and written consent from all participants was obtained prior to study enrollment.

97

98 ***Training***

99           A 10-minute PowerPoint presentation describing the cannulation technique was devised for  
100 all study personnel (presented by the DACVECC) to view prior to study enrollment. Following study  
101 enrollment, each participant (apart from the DACVECC) also viewed a demonstration of the cutdown  
102 technique on a cadaver at each site prior to their cannulation attempts. The DACVECC initially  
103 demonstrated the technique to the intern and then either the DACVECC or intern demonstrated the  
104 procedure to the nurses and students. The time taken for cannulation for each demonstration was  
105 recorded and included in the results of this study for the relevant placer.

106

### 107 *Venous cutdown technique*

108           The cutdown technique has been previously described.<sup>2</sup> Materials required for cannula  
109 placement were readily available at the start of each attempt and included a number 11 scalpel blade,  
110 mosquito forceps, non-absorbable suture material and over-the-needle cannulas<sup>a</sup> with the gauge  
111 selected by the placer. A new cannula and scalpel blade was used for each cannulation attempt. All  
112 cannulation attempts were placed with the cadaver lying in lateral recumbency. To eliminate the  
113 influence of coat type on time to cannulation, the fur over the insertion sites was clipped prior to study  
114 commencement. Aseptic preparation of the site was not performed. An assistant was available to  
115 assist with stabilizing the limb or neck as needed for cannulation. For standardization, each cannula  
116 placer started with the jugular vein followed by the cephalic and then the lateral saphenous vein on  
117 the same side of the body in each cadaver. Each cannulation attempt was timed using a stopwatch by  
118 an independent observer. When the cannula placer was ready to start, the independent observer  
119 communicated that the cannula placer could begin and started the stopwatch. The stopwatch was  
120 stopped when the cannula was visualized to be within the vein and blood identified in the cannula hub  
121 and correct placement confirmed by one of the study investigators (DACVECC or intern). This time  
122 was recorded in seconds and defined as the cannulation time.

123

124           Each cannula placer was given five minutes to attempt cannulation at each site by venous  
125 cutdown. If the time taken exceeded five minutes the attempt was deemed a failed attempt and timing  
126 was stopped. Veins which had been previously cannulated by percutaneous technique prior to

127 euthanasia were included in this study but there was never repeated cannulation by cutdown technique  
128 by more than one attempt into the same vein.

129

130           The breed, body weight and body condition score of each cadaver was recorded. The time  
131 from euthanasia to the start of the attempt and any complications encountered during the cannula  
132 placement were recorded as free text. All cutdowns were aimed to be performed within 4 hours of  
133 euthanasia. The cadavers were stored at room temperature until participants and materials were ready.

134



135 **Statistical analysis**

136 Observations were entered into a computer spreadsheet and data analysis was performed using the R  
137 statistical software<sup>b</sup> and Tidyverse suite of packages.<sup>c</sup> The overall success rates for each group of  
138 cannula placer (DACVECC, intern, RVN, student) were compared using a binary logistic regression  
139 model. Cannulation times were also compared between the four groups of cannula placer  
140 (DACVECC, intern, RVN, student) and also between cannulation sites (jugular, cephalic and lateral  
141 saphenous veins) with linear regression models. The distribution of cannulation times was visually  
142 assessed using histograms and was right skewed so they were log transformed prior to statistical  
143 modelling. Cannulation times were censored at 5 minutes so time comparisons are conditional on  
144 successful cannulation within this time limit. Each subject performed three or more cannulations (at  
145 least one per site) so both regression models included random effects to explicitly include the  
146 potential similarities of success rates and times within each subject's attempts. Models were estimated  
147 using the lme4 R package.<sup>4</sup> After the models were fitted post-hoc paired comparisons were made  
148 between each the three possible pairs of sites and the six possible pairs of subject groups. To control  
149 the risk of falsely identifying a difference between groups that may arise with multiple grouped  
150 comparisons the p-values were adjusted using Tukey's method (using the emmeans<sup>5</sup> and multcomp<sup>d</sup> R  
151 packages). Results tables were generated with the R sjPlots package.<sup>e</sup> A p-value of less than 0.05 was  
152 considered statistically significant.

153

154 **Results**

155 ***Study population***

156 A total of 19 cadavers were considered for study inclusion during the study period and a total  
157 of 18 cadavers were included. One cadaver was excluded due to pathology affecting the limbs which  
158 would have precluded obtaining a full set of cannulation times. Cadaver demographics are shown in  
159 Table 1. Body weight ranged from 5.5 to 43.3kg, with a mean of 25.4kg. The median body condition  
160 score was 5 out of 9 (range 2-8). There was no difference in cadaver weight between the four cannula  
161 placer groups (P=0.84).

162

163 The average time from euthanasia to first cannulation attempt by a placer was 107 minutes  
164 (range 25-405 minutes). A total of 16 out of 18 cadavers enrolled in the study had cannulation  
165 attempts within 4 hours of euthanasia. A total of 8 sets of times were obtained for the DACVECC,  
166 intern and student group. Only 7 sets of times were obtained for the RVN group due to study  
167 enrollment ceasing with the COVID-19 pandemic. One RVN completed 5 sets of times and the other  
168 RVN 2 sets of times.

169

170 One intravenous cannula was present in each cadaver at time of enrollment. The location of  
171 these cannulae were recorded for 9 cadavers. Eight cadavers had a cannula placed into the cephalic  
172 vein and 1 cadaver had a cannula placed into the lateral saphenous vein.

173

174 ***Success rate***

175 The combined rates for successful cannulation of each vein and the rate of successful  
176 cannulation of each vein subcategorized by study group are shown in Table 2 and the results of the  
177 logistic regression model of cannulation success are shown in Table 3. No differences in success of  
178 cannulation by venous cutdown were identified based on cannula placer group or vein used for  
179 cutdown.

180

181 ***Cannulation time***

182           The individual times taken (up to the 5-minute cut-off) for successful cannulation of each  
183 vein by all personnel are shown in Figure 1. The median time taken for all personnel to successfully  
184 cannulate the cephalic, jugular and lateral saphenous veins were 82 seconds, 119 seconds and 110  
185 seconds, respectively (Table 2).

186

187           The individual times taken for successful cannulation of each vein categorized by group are  
188 depicted in Figure 2. The mean and median times for each group by vein location are shown in Table  
189 2. Table 4 shows the results of the linear regression model of cannulation time versus group and site.  
190 No significant differences were identified when comparing the time to cannulation of each site. Post-  
191 hoc analysis with correction for multiple grouped comparisons identified that the DACVECC was  
192 significantly faster than the RVN group ( $p = 0.042$  after Tukey's adjustment) and the student group ( $p$   
193  $= 0.048$  after Tukey's adjustment). No other groups were found to be different.

194

### 195 *Complications*

196           Twenty-six comments relating to complications or difficulties encountered were recorded  
197 from a total of 93 placement attempts (Tables 5 and 6). Ante-mortem factors were encountered most  
198 commonly, namely if the vein was cannulated previously and/or the presence of a hematoma from  
199 prior venipuncture ( $N = 14/26$ ; 53.8%) and associated with a 35.7% ( $N = 5/14$ ) failed attempt rate.  
200 The cephalic vein had the highest incidence of ante-mortem tissue damage (Tables 5 and 6).  
201 Difficulty locating the vein commonly resulted in a failure to achieve cannulation ( $N = 8/10$ , 80%)  
202 (Table 6). Iatrogenic damage to the vein during the cutdown technique occurred on two occasions,  
203 both instances by two final-year veterinary students and resulted in a failed attempt on one occasion.  
204 Of the 15 failed attempts for venous cannulation by cutdown technique, a complication or difficulty  
205 was identified in 13 of these attempts.

## 206 **Discussion**

207           The results of our study conclude that the jugular, cephalic and lateral saphenous veins in  
208 canine cadavers can be readily cannulated using a venous cutdown technique by personnel of varying  
209 experience levels. No significant differences were identified for time to cannulation at each of the  
210 three venous cutdown locations, suggesting that venous cutdown of the jugular, cephalic or lateral  
211 saphenous vein may be considered in emergency situations. However, the intergroup differences  
212 suggest proficiency may improve with increased experience of the venous cutdown procedure.

213

214           Cannulation by venous cutdown technique had high overall success rates for each of the three  
215 sites, with no significant differences in cannulation success rates between groups. All students and  
216 nurses enrolled in this study had limited surgical tissue handling experience and no prior clinical  
217 experience of performing a venous cutdown. The absence of significant differences for successful  
218 cannulation attempts between groups suggests that the venous cutdown technique can be rapidly  
219 learnt with minimal training and performed by all members of the clinical team.

220

221           Unsuccessful cannulation rates of 19.4%, 16.1% and 13% were recorded for the jugular,  
222 cephalic and lateral saphenous veins respectively. We specifically chose to define an unsuccessful or  
223 failed attempt as a cannulation attempt exceeding 5 minutes and not simply failure of VC regardless  
224 of time required. As this technique is usually being performed in patients with cardiovascular  
225 collapse, to include patients having undergone CPA, rapid vascular access is crucial. Therefore,  
226 assessing whether this procedure could be performed within 5 minutes was thought to be clinically  
227 appropriate as opposed to whether a venous cutdown could be performed regardless of time taken.

228

229           To the authors' knowledge, this is the first study to document both the success rate and time  
230 to VC of the cephalic and lateral saphenous vein by cutdown technique in dogs. We documented an  
231 overall success rate of 80.6% for cannulation of the jugular vein by all cannula placers by cutdown  
232 technique, which is lower than the success rate of 87.5% documented in a previously published  
233 study.<sup>3</sup> Although individuals with various clinical experience were also included in the study by

234 Allukian et al, their success rates may not be directly comparable. The time limit of 5 minutes per  
235 attempt in our study, along with ready access to the required instruments highlights major differences  
236 in methodology and is reflected by our shorter median jugular cannulation time (119 seconds versus  
237 217 seconds).

238

239 We hypothesized that the lateral saphenous vein would have the shortest cannulation time  
240 given it is less likely to be surrounded by subcutaneous fat, is often readily visible in canine patients  
241 and due to the positioning of the cadaver in lateral recumbency. However, we did not identify a  
242 significant difference in cannulation times between the jugular, cephalic or lateral saphenous veins.  
243 This suggests that any of these veins could be considered for a venous cutdown. The lateral saphenous  
244 vein may still be advantageous in a CPR scenario given the pelvic limbs are at a distance from where  
245 a member of the team may be intubating the patient, which could hinder placement of a jugular or  
246 cephalic cannula. However, we did not simulate a CPR scenario in this study so we cannot be certain  
247 of these potential clinical implications.

248

249 In human medicine the venous cutdown technique is typically used to cannulate either the  
250 greater saphenous vein either near the groin or at the ankle or the basilic vein above the elbow.<sup>5</sup> In  
251 recent years this technique has largely been superseded in favor of less invasive techniques such as  
252 the modified Seldinger technique to access the femoral vein, use of ultrasound-guidance for  
253 percutaneous cannulation or IO catheterization.<sup>5-7</sup> Although peripheral venous cutdown is part of  
254 Advanced Pediatric Life Support training this technique is now considered to be a last resort.<sup>6</sup>  
255 Nonetheless, peripheral venous cutdown is still considered a valuable skill for emergency physicians.<sup>5</sup>

256

257 Obtaining vascular access is empirical in the treatment of critically ill patients and is part of  
258 advanced life support to facilitate administration of vasopressor drugs and intravenous fluids.<sup>8</sup>  
259 Cannulation of the jugular vein provides an advantage over the peripheral veins due to the jugular  
260 vein's proximity to the central circulation, providing higher peak concentrations of drugs and shorter  
261 lag times compared to peripherally administered drugs during CPR.<sup>9</sup> Therefore, in people if a central

262 venous cannula is in situ at the time of CPA then this route is recommended for the administration of  
263 emergency drugs.<sup>10</sup> The European Resuscitation Council guidelines report that peripheral venous  
264 cannulation is faster, easier to perform and safer than attempting central venous cannulation during  
265 CPR.<sup>10</sup> However, during CPA or shock states peripheral veins are more likely to be vasoconstricted  
266 and difficult to identify.<sup>1</sup> Furthermore, trauma to the limbs may preclude using the cephalic or lateral  
267 saphenous veins. Currently, there are no veterinary guidelines advising on the preferred location of  
268 intravenous cannula placement during CPA.

269

270 A survey conducted in 2010 investigated various aspects of veterinary CPR performed in  
271 practice, to include site and method of cannulation, by board-certified specialists, general practitioners  
272 working in emergency practice and general practice practitioners.<sup>11</sup> The majority of respondents chose  
273 peripheral over central venous cannulation during CPR with at least 90% of all respondents using the  
274 percutaneous approach. Respondents cited the cephalic vein as the preferred location followed by the  
275 lateral saphenous and jugular veins. The estimated mean time taken to obtain vascular access during a  
276 CPA event was reported as 3.17 minutes across all respondents which is similar to the time to  
277 cannulation obtained using the cutdown technique in our study. Therefore, although percutaneous  
278 peripheral venous cannulation is a more familiar technique to veterinary surgeons, RVNs and  
279 veterinary students, cannulation of the jugular, cephalic and lateral saphenous vein can be learnt and  
280 performed in at least a similar time period.

281

282 Should intravenous cannulation prove difficult, a valid alternative in human medicine is IO  
283 catheterization.<sup>10</sup> Intraosseous administration of drugs has been shown to achieve similar plasma  
284 concentrations to central venous catheter.<sup>12</sup> A study comparing the cutdown technique to secure the  
285 saphenous vein with IO catheterization in adult human cadavers found that IO catheterization was  
286 faster and associated with fewer complications than venous cutdown.<sup>13</sup> However, one retrospective  
287 study evaluating IV versus IO catheterization in cardiac arrest patients found return of spontaneous  
288 circulation was achieved more frequently with vascular as opposed to IO access,<sup>14</sup> suggesting there  
289 may be benefit despite the additional time required.

290

291           The use of an automatic rotary insertion device to secure IO access has been investigated in  
292 comparison to jugular cannulation using a cutdown technique in canine cadavers.<sup>3</sup> In this study IO  
293 catheter placement was found to be significantly faster than jugular cannulation regardless of the level  
294 of clinical experience of the person placing the catheter. However, as not all institutions or general  
295 practices will have access to an insertion device, we chose not to include IO assessment in our study.  
296 In comparison, the materials required for the venous cutdown technique are readily available in all  
297 practices and we suggest that all veterinary professionals should be aware of this technique, should  
298 they require emergency vascular access.

299

300           Complications were encountered by all groups in this study. Difficulty identifying the vein  
301 often led to failure for all cannula placers. Ante-mortem factors such as the tissue damage or  
302 hematomas resulting from previous cannulation or venipuncture were also frequent and could not be  
303 avoided given the nature of this study. The cephalic and saphenous veins were most often affected  
304 and likely reflects the increased use of these veins for cannulation and venipuncture during  
305 hospitalization. As these ante-mortem factors were often associated with failure to complete the task,  
306 it would be advisable to use the cutdown technique for an untouched vein if possible. As the intern  
307 and DACVECC encountered hematomas or previously cannulated veins more frequently than the  
308 student and RVN groups it is possible that there was an element of bias with allowing the less  
309 experienced cannula placer to use the side of the cadaver's body with fewer potential complications.  
310 This could have been avoided by randomizing the side of the body to be used by the first cannula  
311 placer, which was not performed in this study. There were also two instances where students caused  
312 significant iatrogenic damage to the vein whilst carrying out the task, one case resulting in bleeding  
313 from the jugular vein and failure to cannulate. In a live patient, this would contribute to morbidity and  
314 potentially mortality, therefore familiarization and practice of this technique prior to use in patients is  
315 advisable.

316

317           There are several limitations with this study. The sample size for this study was small and a  
318 sample size calculation was not performed. For this study we obtained ethics approval to include up to  
319 24 cadavers. This number was based on a previous similar study<sup>3</sup> and our aim was to enroll an equal  
320 number into each group during the study period. Pre-hoc power analysis was considered however it  
321 was felt that it would be difficult given the limited literature available in both veterinary and human  
322 medicine relating to time to cannulation at each site. It is hoped this study will help provide  
323 information on cannulation times for individuals with varying levels of experience and so should  
324 assist future studies investigating venous cutdown, to include ability of study investigators to calculate  
325 meaningful power analyses. Recently deceased canine patients were used as a model of  
326 cardiovascular collapse, however ante-mortem and post-mortem factors such as hematomas at the site  
327 of previous intravenous cannulas may have affected the time taken to visualize the vein and place the  
328 cannula. The location of the previously placed intravenous cannula was not recorded for every patient  
329 and it is unknown how this affected the results. The time taken to start the cannulation attempts varied  
330 between cadavers and in two instances cannulation times were obtained from two cadavers euthanized  
331 more than four hours prior to study commencement. One chondrodystrophic breed, a Shih Tzu, was  
332 also included despite the study exclusion criteria. However, these were all included for analysis due to  
333 the limited availability of cadavers donated for research. Other cadaver factors such as body condition  
334 score or cause of death may have impacted cannulation times. For example, if the patient had a  
335 disease process which resulted in reduced intravascular volume prior to euthanasia this may have  
336 made cannulation more difficult. For standardization, each cannula placer started with the jugular vein  
337 followed by the cephalic and then the lateral saphenous vein on the same side of the body.  
338 Consequently, there may have been increased confidence and proficiency from cannulation of the  
339 jugular vein to the lateral saphenous vein by each individual per cadaver used. There were different  
340 numbers of participants in each cannula placer group. Increasing the number of individuals in each  
341 group, along with the number of attempts each individual performed, may have given us a wider  
342 range of experience levels and skills to compare between groups. Assessment of increased proficiency  
343 with subsequent placement attempts was not performed for the RVN, intern or DACVECC group due  
344 to the variable time periods between cadaver availability and small sample size and so evaluation of a



345 learning effect with the cutdown technique should be explored in future studies. It is also unknown  
346 how having an individual watch the DACVECC or intern perform the VC as part of the demonstration  
347 may have affected their times to cannulation. Despite having two individuals (DACVECC and intern)  
348 demonstrating the cutdown technique, both used the same technique previously described<sup>2</sup>, therefore  
349 it is not thought this would contribute to bias. Finally, the cannulation attempts not being performed  
350 as part of a clinical scenario, e.g. with movement of the cadaver as a result of chest compressions  
351 during CPR; and having all materials readily available prior to study commencement, are additional  
352 study limitations.

353

354 In conclusion, venous cannulation by cutdown technique of the jugular, cephalic and lateral  
355 saphenous vein can be performed with high success rates by personnel of varying experience levels in  
356 canine cadavers within a clinically relevant time frame. No significant differences in time to  
357 cannulation were identified, suggesting that the jugular, cephalic or lateral saphenous vein may be  
358 considered, but a jugular venous cutdown may be associated with increased risk of a clinically  
359 significant adverse event, especially in novice operators. Cannulation failure was common when  
360 using a vein which had previously been cannulated, suggesting a ‘new vein’ should be used when  
361 possible. Further studies are required to assess the venous cutdown technique in canine patients in  
362 clinical situations, such as CPR.

363

364

365

#### 366 Footnotes

367 <sup>a</sup> Jelco IV catheters, Smiths Medical International Ltd, Kent, UK.

368

369 <sup>b</sup> R Core Team (2020). R: A language and environment for statistical computing. R

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371

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380

381

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421 **Table 1.** Demographic information of the cadavers included in the study.

422 BCS, body condition score; CKCS, Cavalier King Charles Spaniel; GSD, German Shepherd dog;

423 GSP, German Shorthaired Pointer

Breed	Age (years, months)	Weight (kg)	BCS (n/9)
Bearded Collie	11y 7m	30.6	4
Border Collie	4y 10m	20.3	3
Boxer	8y 11m	37.1	6
CKCS	7y 2m	15.4	8
Cocker Spaniel	10y 2m	15	4
Cocker Spaniel	8yr 4m	22	7
Crossbreed	9y 9m	27	5
GSD	6y 11m	40.9	4
GSD	8y	38	6
Labrador	2y	24.5	4
Miniature Schnauzer	0y 6m	5.5	2
Otterhound	8y 4m	30	3
GSP	8y	26.5	6
Rhodesian Ridgeback	8y	43.3	5
Shar Pei	3y 2m	16.5	5
Shih Tzu	16y	8.6	5
Springer Spaniel	6y	16	3
Springer Spaniel	8y 8m	20.65	4

424

425

426

427 **Table 2.** Cannulation success rates and cannulation times of the jugular, cephalic and lateral  
 428 saphenous veins for individuals in each of the 4 cannula placer groups (student, RVN, intern,  
 429 DACVECC). Time to cannulation is expressed in seconds as both the mean time and median time  
 430 with range. The number of cannulation attempts at each site is stated along with the median cadaver  
 431 weight.

432

433 DACVECC, Diplomate of American College Veterinary Emergency and Critical Care; RVN,

434 registered veterinary nurse

435

Group	Cannulation attempts at each site (N)	Median cadaver weight (kg) (range)	Vein	Success rate N (%)	Mean (seconds)	Median (seconds) (range)
Student	8	24.3 (15.0-43.3)	Cephalic	6 (75)	153	149 (82-256)
			Jugular	5 (62.5)	161	153 (51-280)
			Lateral Saphenous	7 (87.5)	120	110 (74-227)
RVN	7	16.5 (16.0-37.1)	Cephalic	5 (71.4)	126	69 (67-283)
			Jugular	5 (71.4)	177	174 (105-250)
			Lateral Saphenous	6 (85.7)	160	132 (95-263)
Intern	8	24.3 (15.0-37.1)	Cephalic	8 (100)	118	82 (50-291)
			Jugular	7 (87.5)	141	119 (51-246)
			Lateral Saphenous	7 (87.5)	168	161 (56-294)
DACVECC	8	31.3 (5.5-43.3)	Cephalic	7 (87.5)	82	72 (39-170)

			Jugular	8 (100)	80	68 (51-139)
			Lateral	7 (87.5)	61	55 (41-84)
			Saphenous			
Overall	31	24.5 (5.5-43.3)	Cephalic	26 (83.9)	118	82 (39-291)
			Jugular	25 (80.6)	127	119 (51-280)
			Lateral	27 (87.1)	126	110 (41-294)
			Saphenous			

437 **Table 3.** Results from logistic regression model of cannulation success. Estimates are odds ratios i.e.  
 438 the odds of success for a group or vein divided by the odds of success in the reference group. Odds  
 439 ratios lower than 1.0 imply a lower relative success rate and odds ratios greater than 1.0 a higher  
 440 success rate than the reference group. P-values are for the test if the odds ratio is significantly  
 441 different from 1.0.

442

Predictors	Odds Ratios	CI	p
vein [cephalic]	Reference level		
vein [jugular]	0.77	0.19 – 3.17	0.721
vein [saphenous]	1.35	0.29 – 6.16	0.701
group [DACVECC]	Reference level		
group [Intern]	1.00	0.04 – 23.48	1.000
group [RVN]	0.23	0.01 – 3.63	0.296
group [Student]	0.29	0.02 – 3.70	0.339

443

444



445 **Table 4.** Results of linear regression model estimating log transformed cannulation time. Estimates  
 446 from the model are exponentiated as time was log transformed. These values for each variable level  
 447 can be interpreted as multiplicative e.g. RVN's took, on average, 2.06 times longer than DACVECC's  
 448 (the reference level for personnel group).

Predictors	Exponentiated estimates	CI	p
vein [cephalic]	Reference level		
vein [jugular]	1.18	0.91 – 1.54	0.208
vein [saphenous]	1.05	0.81 – 1.36	0.710
group [DACVECC]	Reference level		
group [Intern]	1.77	1.01 – 3.12	0.048
group [RVN]	2.06	1.20 – 3.53	0.008
group [Student]	1.87	1.16 – 3.02	0.010

449

450

451 **Table 5.** The complications and difficulties encountered by all personnel during cannulation attempts  
 452 according to vein.

453

454 IVC, intravenous cannula.

455

Vein	Total number of cancellation attempts (N)	Difficulty locating vein (N)	Iatrogenic damage during cannulation attempt (N)	Previous IVC and/or hematoma at site (N)
Cephalic	31	3	0	8
Jugular	31	5	1	1
Lateral saphenous	31	2	1	5

456

457 **Table 6.** The complications recorded during cannulation attempts are shown in the table according to  
 458 group. The frequency of each complication is reported and the frequency the complication resulted in  
 459 a failed attempt by individuals in each cannula placer group is also shown.

460

461 DACVECC, Diplomate of American College of Veterinary Emergency and Critical Care; IVC,

462 intravenous cannula; RVN, registered veterinary nurses.

463

Complication	Vein	Study group							
		Student		RVN		Intern		DACVECC	
		Frequency reported (N)	Frequency resulted in failed attempt (N)	Frequency reported (N)	Frequency resulted in failed attempt (N)	Frequency reported (N)	Frequency resulted in failed attempt (N)	Frequency reported (N)	Frequency resulted in failed attempt (N)
Difficulty locating vein	Cephalic	2	1	-	-	-	-	1	1
	Jugular	2	1	2	2	1	1	-	-
	Lateral	1	1	1	1	-	-	-	-
	Saphenous								
Previous IVC and/or hematoma at site	Cephalic	1	1	3	2	2	-	2	-
	Jugular	-	-	-	-	1	-	-	-
	Lateral	-	-	-	-	3	1	2	1
	Saphenous								
Iatrogenic damage to vein	Cephalic	-	-	-	-	-	-	-	-
	Jugular	1	1	-	-	-	-	-	-
	Lateral	1	-	-	-	-	-	-	-
	Saphenous								

464

465

466

467 Figure legends468 **Figure 1.** Scatter plot showing each successful cannulation time by all personnel by vein. Cross

469 indicates median cannulation time.

470

471 **Figure 2.** Scatter plot showing each successful cannulation time by cannula placer group and by vein.

472 Cross indicates median cannulation time.

473

474 DACVECC = Diplomate of American College of Veterinary Emergency and Critical Care, RVN =

475 registered veterinary nurse.

476