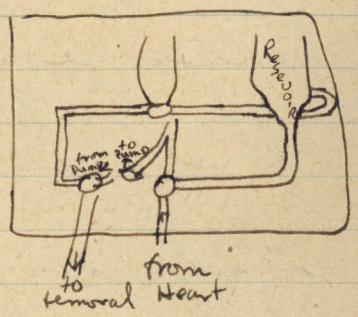
7-27-49

Dog #14 32 lb ♀ Mongrel

Equipment

DeBakey pump as previously described. New control panel to facilitate control of flow, transfusions, volume in system, etc.



Coronary artery occluder to be used compresses artery by means of suture

Procedure

Right chest opened - respirations maintained c̄ pump. Right auricle cannulated. Right femoral artery + vein cannulated as well as right carotid artery. 10 mgm heparin administered I.V. to dog. #3 silk tie around anterior coronary artery.

Data

Time	BP (arterial)	Pulse	Remarks.
1:00	104		
1:06	80		
1:07			50cc transf.
1:08	90		
1:09-10		112	100cc transf.
1:10.5	95	140	
1:12	98		

cont'd

Time	BP (art)	Pulse	
1:03.5			Art. desc. Coronary occluded
1:14	40		
1:14.5	28		
1:14.7			Pumps on dog circuit
1:15	38		
1:16	44		Pressure difficult to record due to clot in tubing.
1:19	Coronary released		
1:20.5		70	
1:21			Heart stopped in diastolic; massage begun.
1:24			Ventricular fibrillation
1:32			Dog expired.

Observations

Again profound drop in arterial pressure noted when coronary occluded.

Mechanical difficulties invalidate this particular procedure. However, following points noted:

1. should put dog on pump before occluding coronary to observe effect of pump alone
2. blood returning to femoral artery dark.

Addition of small oxygenator may be needed.

3/ Noted that serum of blood standing in tubing of pump system to be very pink. Will get serum Hgb.

4/ Right heart produced good venous blood supply. Only one tube of De Bakey pump used.

7-29-49 In an attempt to establish amount of hemolysis produced by DeBakey pump — as well as small Crawford oxygenator — refrigerated, heparized, 3 day old blood was put thru pump + oxygenator + samples withdrawn.

Results

Control (Refrig blood) — 0.459 gms % !
after 30' pump — 0.637
45' " — 0.687
60' " — 0.791

Control (Refrig blood) — 0.588 gms % !
after 15 (oxygenator) — 0.592
30 " — 0.578
45 " — 0.588

DeBakey pump increased Serum Hgb 180% in 1 hr. However, this on old blood c̄ considerable hemolysis initially. Interestingly, if old blood is relatively fragile, Crawford oxygenator failed to take advantage of this tendency. Pump however, appears to be relatively good hemolysis producer.

DeBakey Pumps

7-30-49. Volume of entire "dog-dog" system of DeBakey Pump. — 90 cc
Volume of "Reservoir system — 120 cc
Total volume of pump — 210 cc

Output of pump (3 tubes) — 780 cc/min

(8-9-49) Dog #47 - 40 lb. ♂ mongrel

Purpose of Procedure

With observations on serum Hgbn. + no data on effects of perfusion alone c̄ DeBakey pumps, dog is to be perfused c̄ periodic blood samples being withdrawn.

Procedure

Right carotid artery cannulated to record arterial pressure. Femoral artery cannulated for perfusion. Right atrium cannulated for venous blood supply. Right chest opened. Intratracheal O_2 c̄ pump. Dog given 10 mgm heparin initially - 15 mgm added approx. 15 min. after heart cannulated.

Data

Time	BP(art)	Pulse	Remarks
1:07	140		Dog circuit started
1:09	140		
1:14	120		
1:17	110		10 min sample (#3)
1:27	95		20 min " (#4)
1:28	100		25cc transfusion
1:29	105		40cc transfusion

Time	BP(art)	Pulse	Remarks
1:29.5	105		25cc transfusion
1:33	100		
1:34	100		25cc transfusion
1:37			30 min sample (#5)
1:52	100		45 min " (#6)
2:07	100		1 hr sample (#7)
2:15	105		50cc transfusion
2:22	100		1'15" sample (#8)
2:24	100		50cc transfusion
2:35	90		½ million U. penicillin
2:37			1'30" sample (#9)
2:45			pumps stopped
4:00			chest closed. Gel foam

Blood for transfusion from Puppy #1 - 300cc

Observations

1. Pump (DeBakey) had no apparent effect on arterial pressure.
2. Total cc's transfused during procedure - 220cc
3. Only one tube of DeBakey pumps used - pumped 216cc/minute

Data (additional)

		Serum Hgbn
1. Puppy blood - sample #1		0.084 mgm%
2. Dog #47 - pre pump - #2		0.094 "
3. After 10 min perfusion - #3		0.160 "
4. " 20 min " #4		0.140 "
5. " 30 min " #5		0.160 "
6. " 45 min " #6		0.290 "

7. After 1 hr perfusion #7 - 0.270 mgm %
8. " 1'15" " #8 - 0.210 "
9. " 1'30" " #9 - 0.190 "

Results
- Peak of serum Hgb at 45" + 1 hr after perfusion when serum Hgb levels had increased 300%.
- Dog returned to cage at 5:15 p.m. Dog alive at 5:45 p.m.
- Dog expired during nite.

Autopsy findings: 1. complete atelectasis of right lung
2. Hemothorax, right, moderate.
3. Liver, ~~spleen~~ & kidneys grossly normal.

8-[redacted]-49. Dog #2 ~~51~~ 31 lb mongrel ♂

Purpose

To profuse dog using DeBakey pump & to allow dog to continue on pump until death to observe immediate results of hemolyzed blood.

Equipement

De Bakey pump – 31 lb mongrel ♂

Procedure

Right femoral, right carotid & right femoral cannulated. Dog heparinized c̄ 25 mgm heparin.

Data

Time	BP (art)	Pulse	Remarks
12:22	80		Pump on (3)
12:23			60 cc transf.
12:24	120	152	
12:28	90		
12:32	60	112	Sample #3
12:~~34~~ 35	2 De Bakey pumps	122	clamped
12:42	80	132	Sample #4
12:45	80		
12:49	90		Sample #5
12:52	100		2 tubes of De Bakey tubes open
~~12~~ 1:02	110		50 cc transf

1:07	110	116	Sample #6
1:12	90		
1:17	112	116	50 cc transf.
1:22	110	132	Sample #7
1:26			10 mgm Heparin
1:34	100	120	
1:40	90	120	Sample #8.
1:50	110		
1:55	100	132	Sample #9
2:05	90	132	
2:06			50 cc transf
2:10	118		
2:15	90		
2:22	pumps off — broke.		

Results: Total transfusion 210 cc

Sample #	time	Serum Hgb
1	donor dog	0.084 gms %
2	operative dog	.094
3	10	.16
4	~~20~~	.14
5	30	.16
6	45'	.29
7	1'	.27
8	1'15"	.21
9	1'30"	.19

Quantity of serum Hgb produced in this experiment was much less than anticipated even tho not less than 2 tubes were open at all times.

Dog died shortly after closure of wounds. Autopsy - acute gastric dilatation, no air in coronaries, liver, kidneys & spleen grossly normal.

(24)

8-12-49 Dog #2 51 lb mongrel ♂

Purpose

To evaluate mechanical efficiency of newly organized and revised oxygenator and pumps.

Equipment

Dennis-Karlson oxygenator. Venous pumps - 3 in sequence of phase 120° - rubber bellows. Single arterial pump. New head on oxygenator. Entire unit encased in box c̄ air conditioning unit consisting of fan, 3 4" flexible tubes directing hot air to top of oxygenator stand & two to area of blood reservoir proximal to venous pumps. One exhaust tube - 6" stove pipe - situated in back near junction of venous pumps & oxygenator.

41 lb ♂ dog

35 lb ♂ dog bleed of 2000 cc of blood

Procedure

Both femoral arteries cannulated
Right carotid artery cannulated
Right auricle cannulated after
dog given 20 mgm heparin

Blood gotten from donor
dog placed in reservoir of
D/K machine.

Data

Time	BP (art)	Pulse	Remarks
4:28	160		
4:45	150		
5:00	160		Heparin mgm 10
5:15	155		
5:30	160		
5:35	140		pumps on!
5:42			Art & Ven samples
5:45	120		100cc trans
5:47	120		100cc trans
5:48	110	168	temp of blood 38°C
5:02	120		
5:05	90		Art & Venous samples

Blood pressure of dog
dropped immediately on
turning on machine &
dog expired!

	Donor dog	OP dog
Hematocrit		
Hemoglobin	10.15	14.6
Serum Hgb		

During perfusion, blood clotted
in machine. Additional heparin
added + anticoagulant protamine
studies discontinued. Gooch tubing
in #2 venous pump broke
during run.

Mechanically, D-K machine worked
well

8-16-49

Purpose
To re-evaluate D-K machine.
To repeat prolamine studies,
hemolysis + gas studies

Equipment
D-K machine ♂ 41# mongrel
Blood from donor dog - 30 mgm
heparin / liter

Procedure
Cannulization of both femoral
arteries, right femoral artery,
and right auricle. Dog
given 25 mgm Heparin
(Dunning-Westcott!)

Do Not use Dunning-Westcott
Heparin! (about 1/10th strength
of Connaught heparin)

Data

Donor Dog
Hgb 48.2%
Hematocrit 26.5
Plasma Hgb 0.063 gm %

Operative Dog
Hgb 78.1%
Hematocrit 43
Serum Hgb 0.21 gm %

Time	B.P.	Pulse	Remarks
00	80	138	Machine on
05	95	132	Trans 110cc
10	80		Clotted
15			V+O samples for O_2
20	70		
25			Trans 200
30			Trans 200
35	50	75	
45			Machine off gradually

Dog died immediately post op
of air emboli. Air easily
demonstrated in coronaries

over

Plasma Hgt

Donor - 0.063 gms %
Op. Dog - 0.21
10" - 3.6 gms %
20" - 3.4 gms %

These plasma hgt studies are invalid on this basis. Venous pumps of D-K machine were operating at about 3000 cc/min. The pull on the venous system was so great that air was sucked into machine - air in coronaries of dog - + mechanical action of pumps on blood was very great causing hemolysis

Gas Studies

CO_2 - .13
O_2 - 21.07
N_2 - 78.8

CO_2 - .08
O_2 - 26.00
N_2 - 73.92

Blood gas samples invalid

Conclusions

1. Do not use D-W Heparin
2. Slow venous pumps!

8.22-49 Hemolysis Experiment

Purpose: to determine degree of hemolysis produced by 3 venous pumps, oxygenator & arterial pumps and entire oxygenator as a unit

Dog #12 - bled 800cc - 30 mgm heparin

Plasma Hgb determinations

- Control level - blood - .12 gms %
- Blood thru venous pumps #1-#2-#3 for 10" - .15 gms %
- Blood thru venous pumps #1-#2-#3 for 20" - .16 gms %
- Blood thru pumps #2 & #3 for 10 minutes - .20 gms %
- Blood thru pump #2 alone for 10 minutes - .28 gms %
- Blood thru entire machine for 15 min - 1.4 gram %

Sample blood allowed to stand for time equal to time required for above procedure - .12 gms %

Hematocrit 26.5

Observations

- Rise in plasma Hgb c̄ all three pumps running for 20 minutes was not significant
- Clamping off one pump produced a significant rise (25%) in 10 minutes.
- Clamping off two pumps produced an additional rise of 40% in 10 minutes
- Blood thru entire machine for 15 minutes

Any increased work on part of pumps produces increased hemolysis! in vitro

8-23-49 Gas Analyses:

Purpose: To test accuracy of method of gas analyses.

Procedure: With O_2 delivery set at 10 L/min and CO_2 " " at 600 cc/min samples drawn into greased syringes previously filled with water to make certain all room air out.

Samples taken from 3 sites

#1. From tube at gas machine

#2. " " between humidifier and oxygenator

#3 " near jet #1 at bottom of oxygenator

Results:

1. (Gas machine) CO_2 = 0.26%
(Expect 6% CO_2, 94% O_2) O_2 = 98.8%
N_2 = 0.86%

2. (Into oxygenator) CO_2 = 0.28%
O_2 = 98.43
N_2 = 1.28

3. (From jet) CO_2 = 0.43
Invalid O_2 = 58.17
N_2 = 41.40

↓

No mercury in O_2 intake valve — Repeat

Repeat c̄ Hg seal. CO_2 = 0.31%
at jet #8 O_2 = 93.97%
N_2 = 5.72%

At center of cylinders, samples drawn

	Open	Shaft Closed
CO_2 =	0.26%	0.35
O_2 =	29.16	37.43
N_2 =	70.58	62.22

Conclusions - Over 93% O_2 being delivered at jet orifices. However with bottom of shaft open, room air is sucked into cylinder which reduces oxygen saturation. This will be aided materially by making bottom of rotating cylinder air tight.

8-25-49 Gas Analyses

c̄ flow of Oxygen at 15 liters/min
CO_2 at 900 cc/min

water displacement Shunting humidifier

Sample #1 from jet #8 orifice - CO_2 = 3.54
O_2 = 63.50
N_2 = 32.97

#2 Cylinders running c̄ shaft open
CO_2 = 1.31
O_2 = 30.52
N_2 = 68.17

#3 Shaft closed - 30 min later
CO_2 =
O_2 =
N_2 =
} lost by tech.

8-26-49 Hemolysis by DeBakey - Crafoord machine
24 hr old radioactive blood - 900 cc blood
Hematocrit = 39 start, 1 hr later = 37.5
Volume blood to fill machine = 850 cc
Machine intake + output = 340 cc/min
at 100 revolutions/minute.
Plasma hemoglobin det^n

Start =	0.078	grams %
15 min =	0.101	" "
30 min =	0.124	
45 " =	0.14	
60 " =	0.152	

8-29-49 Gas Analysis
15 l O_2/min
600 cc CO_2/min

From jet - CO_2 3.527 %
O_2 90.767
N_2 5.720 %

From Cylinder CO_2 1.197
O_2 35.847
N_2 62.980

8-30-49

Purpose
To attempt to occlude anterior descending branch of coronary artery and perfuse dog using DeBakey-Crawford machine to maintain B.P.

Material
DeBakey pumps - 2 sets of rotors & tubes + Crawford oxygenator. 12 lb of pup

Procedure
Cannulization of right carotid & femoral arteries & right atrium

Data

Time	BP	Pulse	Remarks
2:50	40	100	Dog in shock. Trans/ 100 cc
2:58	30		
3:00	40		Trans/ 100 cc
3:01	45		
3:03	50		
3:12	40	60	350 cc blood added to oxygenator
3:20			
3:25	40		Trans/ 200 cc
3:26			250 cc to oxygenator

3:27	40	Dog being constantly transfused from oxygenator
3:30	50	
3:31	55	
3:35	55	
3:42	60	
3:50	?	Clamp on Right A-V septum
3:51	40	
3:57	40	
3:60		Ventricular fibrillation
3:60.5	20	
3:65	20	
4:15		Dog dead

Coronary never occluded because dog in constant shock. It was noted that vena cava of dog was almost collapsed, & it was then decided to attempt to use dog as a perfusion experiment on a small scale. Output of pumps — 400 cc/min of machine about 800 cc. Efficiency of Crawford oxygenator appears excellent (10 l O_2 - 600 ml CO_2)

Plasma Hgt #1 (Donor) .027 #4 (20") .041
#2 (Dog) .034 #5 (30") .062
#3 (10 min) .036

(26) Bleeder

9-2-49

Purpose

Due to fact that the venous pumps on D-K machine were run at 3000 cc/min and, in so doing, collapsed venous system of dog so that air was sucked into machine and trauma to blood raised plasma hemoglobin very high, a variable speed pulley has been inserted between shaft of arterial pumps & venous pumps. This enables the output of the venous pumps to be varied from 800 cc to 2400 cc/min to arterial shaft at 50 RPM. By increasing arterial shaft RPM to 100, output of venous pumps may be raised to 4000 cc (springs tight!)

It is proposed to alter speed of venous pumps so that vena cava is almost collapsed.

Equipment

1. D-K machine & variable speed venous pump
2. 40 lb mongrel ♂ dog

Conditions of Experiment

O_2 — 10 l/min
CO_2 — 600 cc/min
Arterial shaft — 50 RPM
Venous output — 1100 cc/min
Temp of venous blood — 38° C
Temp of arterial blood — 37° C
1000 cc donor blood c 30 mgm/dyne

Data

Time	BP	Pulse	Remarks
1:36	130		
1:37	100		machine started
1:40	130	100	V. cava almost collapsed
1:43	110	100	
1:45	90		Arterial blood dark
1:46	100		O_2 incr to 15 l/min
1:49	90	110	
1:52	100		
1:54	95		100 cc transfusion
1:55	100		
1:58	100		
2:01	100		

	2:04	95	
32	2:05		off machine
	2:06	100	
	2:15	80	Saline IV
	2:30	40	Saline IV
	2:45		Dog died

Donor Blood.
Hematocrit — 26.5 %
Plasma Hgt — 0.102

Operative Dog
Hematocrit — 27.5 %
Hgt — 10.5
Plasma Hgt — 4.08

Plasma Hgt
10 min — 4.29
20 min — 3.78
30 min — 3.2 (whole blood clotted)

Gas Analysis
CO_2 — 1.0 %
O_2 — 36.75 (15 l./min)
N_2 62.24

Autopsy
Dog had large quantity blood in chest.
Blood gas samples — clotted!

Conclusions

1. Major problem is bleeding
2. Pump (V) run at 1100 cc/min
   left vena cava collapsed
3. Mechanically D-K machine good
4. Add heparin to blood gas samples!

(37) Bleeder

9-6-49

Purpose

To repeat protamine studies + concomitant studies - on dog to D-K machine.

Equipment

50 lb mongrel dog ♂
D-K machine
- 3 venous pumps
- 2 arterial pumps
- 5 rotating cylinders
- air conditioned

Conditions of Experiment

RPM - arterial shaft - 50
RPM - venous shaft - 25
O_2 flow - 15 liters/min
CO_2 flow - 900 cc/min
Temp - art. side - 37°
Temp - venous side - 36.5°
Rate of blood flow - 1200 cc/min
Heparin (Connaught) - 30 mgm/liter of donor blood; 50 mgm in dog

Procedure

Cannulization of both femoral arteries, right carotid artery + right auricular appendage. No change in usual technique.

9-6-49

(A) Data

On Dog During Procedure

Time	B.P.	Pulse	Remark
1:50 (pm)	170		Carotid Cannula in
1:53	140		Chest open
1:58	130		Heart being manip
2:00	130		Cannula in rt auricle
2:03	140		
2:06	150	160	
2:11	140		Dog on machine
			Machine off! Broken arterial connection due to clamp on tube
2:16	110		Machine on!
2:18			Trans/ 100 cc
2:24	70		Trans/ 150 cc
2:24.5	90		
2:25	110		
2:26.5	110	112	Vena cava collapsed + auricle.
2:31	85		Transf. 100 cc
2:32	90		
2:34	95	128	
2:37	90		
2:39	85		Transf 100 cc
2:44	80	120	
2:46			Venous side clamped
2:46.5	100		Transf 100 cc

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	2:47.5	100	arterial side occluded
30 min	2:48	110	
	2:52		50 mgm protamine I.V to dog
	3:16		
	4:30.	Protamine mgm 25	Chest closed
	6:00.	80	M. membranes blanched. Dog #5 sacrificed. Given 600 cc citrated blood. 1 Gm Ca gluconate IV
	7:30	110	Dog #6 sacrificed 450 cc transfusion
	7:40	140	
	7:50	140	Clotting time (small glass tube) 5 min
8.00 to 11 pm			B.P. varied 160 to 120. At 11:15 BP fell to 100 + rapidly to 0 in spite of saline
	200 cc transf.		
			Dog dead.

(B) On Blood

1. Hematocrit - #1 (reservoir) - 21
   #2 (Dog - pre perf) - 55
   #3 (20 min) - 36
   #4 (30 min) - 42

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2. Plasma Hgb #1 (reservoir) – .0168
#2 (dog prepar) – .224
#3 (10 min) – .944
#4 (20 min) – .104
#5 (30 min) – 1.238 (???)

3. Hgb #1 (dog prepar) – 16.14 gms
#2 (at 30 min) – 14.21 gms.

4. Coagulation Studies
Clotting time on dog (preop) – 5 min
Bleeding time on dog (preop) – N.

Tube No.	Blood	Protamine (30 γ/cc)		Clotting T
A	2cc	0	0	—
B	"	30 γ	1cc	—
C	"	45 γ	1½	—
D	"	60 γ	2	20'
E	"	70 γ	2⅓	20'
F	"	80 γ	2⅔	20'

Blood from operative dog 20 min pt heparin injection (before perfusion).
(Dog given 35 mm Heparin IV 12:55 pm

Tube no	Blood	Protamine	
A_2	2cc	0	all clotted in 5 minute
B_2	"	30 γ	
C_2	"	45 γ	
D_2	"	60 γ	
E_2	"	70 γ.	
F_2	"	80 γ	

9-6-49

Blood from operative dog 20 min after perfusion started.

Tube no	Blood	Protamine	Clotting T
A_3	2cc	0	∝
B_3	"	30 γ	∝
C_3	"	45 γ	∝
D_3	"	60 γ	∝
E_3	"	70 γ	∝
F_3	"	80 γ	13'

Blood from operative dog at 3:50 pm, e.g. 1 hr post perfusion

Tube no	
A_4	all clotted at 25 minutes
B_4	
C_4	
D_4	
E_4	
F_4	

Blood from thigh hematoma at 10:30 pm – 7:45 minutes post-perfusion

	Protamine	Blood	Clotted T 15"	2 3"
Plain glass tube	0	2cc	Cl	Cl
Silicon tube	0	2cc	Fl	Fl
Plain glass tube	60 γ	2cc	Cl	Cl
Silicon tube	60 γ	2cc	Fl	Cl

*Cl ≡ Clotted
Fl ≡ Fluid

9-6-49

(c) Gas Analyses

from oxygenator (at 10 min) CO_2 - 3.27
O_2 22.57
N_2 - 77.1

from oxygenator (at 20 min) CO_2 - .267
O_2 - 26.21
N_2 - 73.5

Blood - at 10 min Art - 20.355 Vols. %
at 20 min Art - 17.684 Vols %
at 10 min Ven - 7.844 Vols %
at 20 min Ven 6.328 Vols %

Hgb #1 - 16.14
x 1.34
6456
4842
1614
21.6276 O_2 Saturation Vols %
20.36 / 21.63 = 94.1% saturation

$A_1 - V_1 = 12.511$
$A_2 - V_2 = 11.256$

Hgb #2 14.21
1.34
5684
4263
1421
19.0414 O_2 Saturation Vols %
17.68 / 19.04 = 87.6% Saturation

9-6-49

Conclusions

Autopsy - Dog died of hemothorax, relative anoxia due to low hgb. No air emboli.

1. Dog lived 8 hrs + 29 minutes post perfusion. Throughout this time he continued to bleed from all wounds. Dog had a total of 125 mgm of protamine IV. given as follows:
   - 50 mgm immediately post perfusion. This was calculated on basis of 30 8/cc needed to clot blood in 20' in tube.
   - 50 mgm to cover 500 cc transfusion (containing 30 mgm) giving dog additional 30+ mgm
   - 25 mgm 1 hr 45" post perfusion
2. Dog received total of
   550 cc W. Blood during perfusion
   1750 cc W Blood - post perfusion
   (1250 cc ≈ heparin)
3. Dog maintained BP well - No labored respiration. Good corneal reflex.

4. Bleeding malicious. Three factors observed.
   - 5 hrs post perfusion, capillary clotted time normal but dog still bleeding
   - Protamine seemed to have no effect in vivo
   - Protamine in vitro, clotted blood at 1 hr post perfusion in concentration of 10 8/cc
   - Siliconed glass tube c̄ protamine (30 8/cc) clotted in 23" after almost 8 hrs of post operative time had elapsed
   - Clotting time (capillary) was 5 min at 5 hrs post perfusion.
5. No difficulties c̄ D-K machine. Appears to be oxygenating well + mechanically ok except for which poor effect as blood comes out of shaft.

(28)

9-8-49

Purpose

In an attempt to determine whether length of time of perfusion (i.e., # of changes of blood volume in donor + theoretically # of transfusions) is directly proportionally to the bleeding factor observed which produces prolonged bleeding in last 5 dogs.

Conditions of the Experiment

RPM - arterial shaft - 50
RPM - venous shaft - about 26
Rate flow - 1500 cc/min
5 rotating cylinders
O_2 flow - 15 l./min } no vaporizer
CO_2 flow - 900 cc/min }
Temp arterial - 37.5° C
Temp venous - 37° C
Heparin (Connaught) - 30 mgm/l donor
25 mgm dog.

Equipment

D-K machine c̄ vaporizer
55 mongrel ♂ dog

Procedure

Cannulization of both femoral arteries, right carotid & right auricle.

Data

(A) On Dog During Procedure

Time	BP	Pulse	Remarks
00	180	120	↓ Machine on
02	80		
04	120		Perfuse stopped
06	140		
07	140		

Chest closed c̄ catheter in site
Dog died 2 hrs post perfusion —

(B) On Blood

1. Plasma Hgb
   #1 - donor - .012 gms %
   #2 - dog - .289 gms %
   #3 - 2" - .0540 "
   #4 - 10" - .0720 "

2. Hgb
   #1 - donor - 5.24
   #2 - Machine - 9.31

3.

Tube no	Blood	Protamine	Clotted
A	2cc	0	Fluid 30" + 45"
B	"	30	11'
C	"	45	3'
D	"	60	11'
E	"	75	11'
F	"	90	30'

Dog given 35 mgm Heparin at 1:10
Dog given 40 mgm protamine at 2:47

3:45 p.m. 300 transfusion
4:00 p.m. Protamine 10 mgm
4:08 p.m. Clotting time 8 min BP 100
4:20 p.m. 350 cc transfusion
(10 mgm heparin - 10 mgm protamine)
4:40 p.m. 15 mgm protamine.

Blood given
During perfusion - 0
After perfusion - 650 cc

Heparin given
45 mgm + that is blood in machine

Protamine - 75 mgm given

Blood O_2
Arterial - Anticipated - 12.475 vols %
Real - 10.528 vols % (84%)

Venous - Anticipated - 15.475 vols %
Real 5.151

A-V = 5.379 x 15 =

Autopsy Dog died of hemo-pneumothorax.
Bleeding time 8 min at 5 hrs post perfusion

9-12-49 Purpose

Because of the malicious bleeding noted post perfusion, the following experiment is to be carried out:

Dog A - 1. Complete all steps necessary to perfuse dog
2. Do not perfuse - allow dog to remain during time necessary for perfusion
3. Give Heparin & Protamine
4. Close chest, etc
5. Take clotting times

Dog B - 1. Cut down on both femoral vessels
2. Give dog all of blood from D-E after the blood had been run thru machine for 30 minutes
3. Take clotting times.
4. Give protamine to counteract Heparin.

This should separate cause of bleeding, machine, dog, drug etc.

9-12

Conditions of Experiment

32 ♂ mongrel A
30 ♂ mongrel B
Anesthesia - pentothal

Experiment A

Both femoral arteries cannulated; right carotid cannulated & right auricle cannulated.

Chest and all wounds left open for 30 minutes. Dog given 15 mgm heparin IV prior to cannulization of vessels & heart. (12:26 pm)

Wounds closed

Clotting time never exceeded 8 min

Tube	Blood	Protamine	Clotting time
A	2cc	0	8
B		10	5
C		20	5
D		30	5
E		40	5
F		50	8
G		60	14

15 mgm protamine IV at 2:45 pm

9-12

During surgery a considerable blood loss was noted.
Dog BP averaged 100.
Approximately 3 hrs postoperatively dog died. Autopsy revealed dog chest wound to little or no blood in chest. Mild atelectasis.

Conclusions

Heparin did not produce profounded bleeding or protamine returned clotting time to normal in 1 hr.

9-12
9-17-49

Bleeding

Dog 1 (path sections)

Experiment B.

Pentothal anesthesia

Bilateral inguinal incisions made in 35 lb ♂ to expose femoral vessels
Cannula in left femoral artery
To withdraw blood equivalent to amount of DK blood infused by IV into right femoral vein.

Condition of dog

Infused blood was completely hemolyzed with a plasma hemoglobin of 6. grams %.

Infusion started 4:15 P.M.
Blood letting

Shaking chill

1150 cc hemolyzed blood c̄ 35 mgm Heparin
1150 cc dogs blood withdrawn.

Heparin injected I.V. 10 mgm at 4:20 PM
20 mgm at 4:37 PM

Clotting times: (Capillary)
4:24 = 6 minutes
4:30 = ∞
4:40 = ∞
4:50 = ∞

Vomiting

Plasma hemoglobin on dog 4:55 =
6:15 =

Protamine, 65 mgm, given IV at 5:06

Clotting times at (Capillary)
5:14 ∞
5:24 ∞
5:40 ∞

Anesthesia light

Bloody vomitus

Test tube 5:45 = 30 min

Venous blood	Silicone tube	Thromboplastin crystals	Clotting Time
2cc	yes	absent	∞
2cc	yes	present	one minute

condition of dog

In view of observation that thromboplastin would cause this blood to clot, following experiment done

	Tube	Blood from vein at 6:15	Protamine 20 γ/cc	Thromboplastin mgm	Clotting Time
	A	2cc	0		∞
Vomiting blood	B	2	1/2 cc		∞
	C	2	1 cc		∞
	D	2	1 1/2 cc		∞
	E	2	2 cc		3-4 hrs
	F	2	2 1/2 cc		15'
	G	2	3 cc		25'
	H	2	0	0.0	∞
	I	2	0	0.1	15'
7:00 PM	J	2	0	0.2	9'
Bloody stool	K	2	0	0.3	9'
	L	2	0	0.4	9'
	M	2	0	0.5	9'
Dog apathetic + reacting	N	2	0	0.6	9'
	O	2	0	0.0	∞
	P	2	0	1	3'30"
	Q	2	0	2	3'30"
	R	2	0	3	3'30"
	S	2	0	4	3'30"
	T	2	0	5	3'30"
	U	2	0	6	3'30"

From this we observed that 0.1 mgm thromboplastin/cc blood brought clotting time from infinity to normal of 9 minutes.

9-12-49

condition of dog

Therefore, thromboplastin 150 mgm (in 500cc saline) was started I.V. (assuming blood volume to be 1500cc) slowly (32 drops/min) at 7:55 P.M.

Currant jelly stool

Capillary clotting times 8:00 PM. 05 min = ∞
15 min = 12 min
25 min = 8 "
29 min = 8 "
35 min = 8 "
45 min = 8 "
50 min = 7 "
55 min = 4 1/2 "
8:55 PM 60 min = 3 "

Appearance better
Still apathetic

IV stopped – 250cc run in (75 mgm thromboplastin)

9:30 PM clotting time again = ∞
9:45 " " " " = ∞

∴ Remaining 250cc saline c̄ 75 mgm thromboplastin started IV. IV. ran well at all times + never clotted c̄ 18 gauge needle.

I.V. Restarted at 9:53 PM

Capillary clotting times 10:10 PM (17 min) = 15 min
10:20 PM (27 min) = 10 min

Infusion rate doubled 68 gtts/min. = " "
10:40 = " "
10:50 = " "

Still bleeding.

Resp. slow

Death between midnight and 8:00 AM.

Autopsy: GI tract edematous + lumen contains blood. No ulceration. Kidneys small + hemorrhagic. Lungs c̄ interstitial hemorrhage – no edema. Colon granular. Sections taken of stomach, small intestine

large intestine, spleen, liver, pancreas: kidney, heart + lung. No intravascular thromboses found except post mortem clots. One suggestive ante mortem thrombus in rt. ventricle

Conclusion: The infusion of completely hemolyzed blood + heparin + protamine caused an hemorrhagic state c̄ prolongation of clotting time. The clotting time can temporarily be restored to normal by thromboplastin.

Dog 2

Bleeder

9-13-49

Purpose of Experiment

Blood to be drawn from 2 dogs, A + B. Blood A to be given to be run thru D-K machine + given to dog C. Blood B to be given to dog D as straight IV. transfusion — to determine effect of massive infusion of blood to a dog in relation to massive infusion of blood that has been in D-K to a dog.

Conditions of Experiment

D-K machine - all 3 v. pumps
2 arterial pumps
5 rotating cylinders
Temp 37°
O_2 - 15 l/min
CO_2 - 900 cc/min

Dog A - x match c̄ C - ok
Dog B - x match c̄ D - ok
30 mgm Heparin/liter blood

Data

Experiment A

- 1200 cc A blood in D-K machine for 30 minutes. Then given to dog C (1200 cc withdrawn)

over

9-13-49

Plasma Hgb

Blood A before D-K		.0146 gms %
Blood A after D-K		3.16 gms %
Dog C	30 min after transf	3.11
"	1 hr " "	2.45
	2 hr	2.9
	3 hr	dead

Wt about 35 #

Clotting times

Dog C	- 30 min after transf	10'
	1 hr "	22'
	1½ hr "	20'
	2 "	19'
	2½ hr "	20'
	died 7:15 pm	

Hematocrit

Blood A - 27.5 (before D-K)
" A - 21.0 (after D-K)

Autopsy - marked hemorrhagic appearance to spleen + kidney as well as slight in lung. Specimens taken large + small bowel granulomas.

9-13-49 Data cont'd

Experiment B

1400 cc B blood to dog D IV
30 mgm Heparin/liter
1400 cc taking from dog

Plasma Hgb

Blood B before transf	-	.206 gms %
Dog D 30" after "	-	.239
Dog D 1 hr " "		not done
Dog D 1½ hr		.2102
Dog D 2 hr		.2041
Dog D - next am.		.0661

Clotting times

30" after transf	-	16"
1 hr " "		12"
1½ hr " "		12
2 hrs " "		5"

Dog alive 24 hrs
Dog alive 48 hrs.

Note: Initial plasma hemoglobin high throughout. This most likely due to fact of improper heparin solution technique. 100 mgm powder dissolved in 100 cc Distilled water which meant 30 cc DW was injected in each liter of blood. R.M. Nelson 12-8-49

9-15-29 Conclusions

Dog given hemolysed blood (from D-K machine) - died in 2½ hrs. Clotting time remained up.

Dog given straight I.V. transfusion lived. Clotting time normal in 3 hrs.

Hemolysed blood produces bleeding apparently. This may be due to hypo-prothrombinemia

9-14-29 Purpose

To attempt to localize foci of hemolysis in D-K machine.

Conditions

Blood thru entire machine to re-evaluate the D-K set-up.

Plasma Hgb

premachine	0.184 gms %
10"	.054 "
20"	.613 "
30"	.777 gms %

Conclusions

Machine will have to be run in units to determine foci.

9-15-49 Purpose

To localize foci of hemolysis in D-K machine

Blood thru venous pumps

8-22 control .12
pumps 1-2-3 for 10 min .15
pumps 1-2-3 for 20 min .16
pump 2-3 for 10 min .20
pump 2 for 10 min .28
entire machine 15 min 1.4

Blood thru Oxygenator alone
Control 0.006 gms %
Oxy. only 1.48 gms %
art Pump + Oxy 1.50 gms %
art Pump #1 only + oxy 1.52 gms %
9-16-49 Thru Oxygenator jets only — too little to read
" Cylinder alone — .1232 gms %

Bleeder

9-16-49 Conclusion — hemolysis is not mechanical & not localized — Is due to faulty cleaning? Leaching?

9-17-49 Purpose:

Dog 3

To determine effect of large transfusion of hemolyzed blood on normal dog. Blood hemolyzed by shaking + standing 3 days.
15 lb dog infused into left femoral vein
catheter in l fem artery for blood-letting.

Anesthesia - IV pentothal
Anticoagulant Heparin 30 mgm/L

Over 45 min period, 900 cc of blood c̄ plasma hemoglobin of 1.77 grams % infused while removing 800 c̄ from artery over same period of time.

10 c̄ protamine clotted 1 cc blood in vitro

Data:		Clotting time	Prothrombin Time	Pl. Hgb
	Transfusion blood	∅	?	1.77
	Dog preop	< 3 min	10 sec	0.0
3:45	45' p̄ infusion begun	∅	8 sec	
	60' " " "	∅	10 sec	2.46
	90' " " "			2.68
	5 hours " " "	8 min (cap)	10 sec	2.465
	5½ hrs " " "	2 min (cap)	10 sec	
	6½ hrs	(test tube = ∅)		2.42

Observations:

Dog had shaking chill p̄ infusion begun. Blood stools observed in 3½ hrs continued into the evening. No vomiting but wretching occured. Arterial cannula never clotted. Hemoglobin at 6½ hrs = 8.35 grams % Dog Condition critical at 7 hrs

Prothrombin time results same by using either of two methods on heparinized blood.

A. Protamine (2 gtts) + Heparinized blood + $(Na)_2(Ox)$ + $CaCl_2$ + Thromboplastin

B - Heparinized blood +11' + "

In vitro, the incoagulable blood will clot when following are added: A thromboplastin
B. + thrombin

Conclusion

A. Massive transfusion of blood c̄ plasma hgb of 1.7 grams % reproduces bleeding syndrome

B. Prothrombin, Calcium, fibrinogen thrombin are apparently adequate

C. Thromboplastin and platelets need further study

D. Clotting time regresses toward normal inspite of no protamine

Dog 3

NOTE: Dog (#3) died approx. 24 hrs after infusion started.

Autopsy findings similar to previous 2 dogs given hemolyzed blood, i.e. contracted granular appearing gastrointestinal tract with edematous hemorrhagic mucous membranes; lungs showed interstitial hemorrhage c̄ small pulmonary infarcts; small amt. fluid in pericardial sac; nutmeg liver + spleen; & boggy red kidneys. Sections to be made.

Conclusion - 3 day old heparinized blood, 900 cc which was shaken for 5 minutes to produce plasma hemoglobin of 1.7 grams % was sufficient to reproduce hemorrhagic syndrome + death.

Laura Jane started 9/19/49

(29)

Sept. 20, 1949 Perfusion on D-K machine

"Uno"

Purpose: With newly acquired knowledge that infusion of hemolyzed blood will cause hemorrhage + death, we have endeavored to eliminate hemolysis by machine by scrupulous cleansing with Slim and 70% ethanol - and will perfuse dog paying strict attention to plasma hemoglobin levels. Zephiran not used to clean machine. New tubing wherever feasible - all glass/plastic surfaces siliconed.

Conditions

- RPM - arterial 50
  venous 25
- Flow (Blood) 1500 cc/min
- 15 l O_2 - 900 cc CO_2/min
- Copper jacket on oxygenator
  $\bar{c}$ O_2 inside jacket
- Temp 36.5 venous
  37 arterial
- Heparin - liquamin
- 5 cylinders

70% alcohol for sterilization

Procedure

Cannulization of both femoral arteries, right carotid artery & right auricle.

Equipment

D-K machine
50 lb mongrel ♀

Data

Crossmatch

Dog A (Donor) - $\bar{c}$ B C D ok
Dog B (OP) - $\bar{c}$ A C D ok
Dog C (Donor) - $\bar{c}$ A B D ok
Dog D (Donor) - $\bar{c}$ A B C ok

Clotting times (test tube)

Dog A - 60 sec
Dog B - 80 sec
Reservoir - 10" N. Done

Prothrombin times

Dog A 8 sec
Dog B 10 sec

Plasma Hgb

Dog B (op) 0.308 gm %
Reservoir (start) 0.493
Arterial 10 min 0.477
Arterial 20 min 0.458
5 02 pm (1½ hrs post perf) Dog 1.109
8 30 pm (5 hrs " ") Dog 0.790

9-20 contd

Plasma Hgt (cont'd)

Dog 9-21-49 .0.951

9-22-49 0.293

Because Cooch tubing broke in #2 pump 3 plasma Hgt levels were taken to insure that no hemolysis had occurred.

#1 - .505

#2 - .487

#3 - .400

Data During perfusion

TIME	B.P.	Remarks
3:07	80	
3:08		Dog on
3:09	80	pulse 150
3:09½	70	
3:11.5	0	
3:13		200cc transf
3:14	45	
3:15	50	
3:18	80	
3:20		300cc transf
3:21	80	pulse 128
3:22		150cc transf.
3:23		Dog off
3:24	90	
3:30	110	
3:34	120	

Gas Analyses from Oxygenator - #1 30% -

#2 70% (flush)

#3 - 80% (flush)

Postoperative Dog

9-20-49 - Plasma Hgt

1½ hrs - 1.109

5 hrs .790

penicillin - 500,000 U

N + in chest

Clotting time - 6 PM

(2½ hrs PP) - 12"

3 hrs PP - 4"

Temp. 40°C

8:40 pm (5 hrs pp) - Dog drinking

9-21-49 - plasma Hgt - .951

BUN 15

Can not use hind leg

9-22-49 - plasma Hgt .293

urinating

.6 gm strepto

.500 U penicillin

Conclusions

Dog on machine 16 minutes. Following mechanical difficulties were noted mechanically

① Goochs tubing broke #2 jump. Pumps filled c̄ saline avoided hemolysis

② Dog's BP dropped at beginning of perfusion — this was due to fact that arterial pumps failed to keep up c̄ venous pumps.

Dog living immediately p-o and was up drinking 5½ hrs postperfusion.

9-23-49 Dog walking — will not use left back leg.

9-25-49 Dog ok — Walks well

10-6-49 Dog alive — all wounds healed

11-17-49 Dog well July 1, 1950 Dog well

9-22-49 Purpose

To determine clotting times on blood, which has progressively increasing quantities of plasma hemoglobin, — Increased by shaking

Protamine added to blood in quantities determined to be equal to heparin action.

Clotting time

— determined from moment protamine added 'til clot occurs.

	Pl. Hgb		Clotting time
1	— 57 × 25	1.4 grams %	< 10 sec
2			< 10 sec
3			2 min
4	— 47		5'
5	— 19	4.7 grams %	5'
6	— 23		2'

57
25
285
114
1,425

19
25
95
38
475

Conclusions:

There is no apparent direct relationship between quantity of pl. Hgb & clotting time.

(30)

9-25-49

Purpose

To perfuse animal c̄ D-K machine and study hemolysis, oxygenation, physiological effect on animal & to attempt to maintain dog post-perfusion.

Equipment

D-K machine - 3 V. pumps
2 arterial pumps.
44 lb mongrel ♂
Air conditioner - copper jacket

Conditions

RPM - arterial shaft - 50
Venous shaft - 24
Rate flow (blood) - 1500 cc
O_2 flow - 15 l/min
CO_2 " - 900 cc/min
Anesthesia - pentobarbital Na
Heparin - liquaemin
Temp - Venous - 38
Arterial 36.5
5 cylinders

Method

Cannulization of brachiocephalic artery for perfusion. - Right auricle to inf. v. cava & azygos v. to superior

9-25-49 cont'd

vena cava. femoral aa. for B.P.

Data

On Dog During Procedure

Time	B.P.	Pulse	Remarks
3:52	160	-	Dog on
3:56	150		
4:00	110		150 cc transf
4:02	120		
4:03	110		100 cc transf
4:04	100		100 cc transf
4:06	100		150 cc "
4:08	100		
4:11	60		150 cc transf
4:15	dog on his own		
4:18	60		
4:30	dog dead.		

Perfusion time 22 minutes

On Blood

① Crossmatch
Donor A c̄ op dog - ok
Donor B c̄ op dog - ok
Donor A c̄ Donor B - ok

② Clotting times
Operative dog 7 min
Donor dog A 7.5 min

9-25-49 cont'd

③ Heparin - Protamine Antagonism

Protamine (8)	blood	Clotting time
0	2cc	2 min
20	↓	↓
30		
40		
50		
60		

④ Prothrombin times. Coagulable blood except (H)

Donor A — 7"
Donor A+B — 25"
Operated dog — 5"
Post perfusion — 10" (H)

⑤ Hematocrits

Reservoir prior to perfusion	22
" pre perfusion	17.5
Op. dog preoperatively	44.
15" perfusion	32

⑥ Plasma Hgb

Donor A	less than	.012 gms%
Op. Dog	"	.012 "
Reservoir	"	.012 "
5" perfusion	"	.012
15" "	"	.012
30 post perfusion	"	.012
90 " "	"	.012
Reservoir post perfusion	"	.012
Suction trap	"	.012
Dead Dog	"	.012

9-25-49 cont'd

⑦ Gas from cylinders
68% — pyrogallic acid method

⑧ Blood Gas Analysis

	Van Slyke Reading		
A_1 (5 min)	46.2	46.8	
A_2 (15 min)	33.0	—	temp 29°
V_1	14.3	13.8	(3.299)
V_2	17.4	16.9	(4.059)

		CCs min
Hgb ≡ A_1	10.16	A_1 = 11.985
Hgb ≡ A_2	9.35	A_2 = 89.35

Anticipated O_2	-	13.61	A_1
Actual O_2	-	11.02	A_1
Actual O_2	-	7.73	A_2
Anticipated O_2	-	12.53	A_2

% O_2 saturation A_1 = 81%
% O_2 " A_2 = 61.7%

Conclusion

Autopsy No air in coronaries; no massive hemorrhage; no apparent emboli
- considerable loss of blood during surgery - avoid
- Oxygenation poor! after 15 min - ?

9-25-49 cont'd

- dog died of shock + anoxia
- entire procedure fraught w/ various difficulties, Valves stuck - two incisions in dogs chest - cannula slipped out w/ considerable blood loss.

No hemolysis !!

(31)

9-27-49

Purpose

To perfuse animal on D-K machine reverting to former method of surgery + to again study physiological aspects of the perfusion

Equipment

D-K machine
45 lb ♂ mongrel

Conditions

RPM - arterial shaft - 50
venous shaft - 34
Flow - 1400 cc/min
O_2 flow - 15 l./min + flooding
CO_2 " - 900 cc/ "
Anesthesia - pentobarbital Na
Heparin - Liquaemin
Temperature - arterial - 37
Venous - 37.5
4 cylinders -

over

9-27-49 cont'd

Data

On Dog During Perfusion

Time	BP	Pulse	Remarks
2:47	110	160	
2:49			Dog on
2:49.5	80		
2:49.6	60		
2:49.8	40		
2:50	60		
2:50.5	80		
2:50.8	90		
2:51	90		
2:52	78	160	
2:52.5	90		-100cc transfusion
2:53	60		-oxygenating well
2:54			-sample A_1. Venous pumps slowed
2:55	92		sample V_1 -
2:56	90		
2:56½		180	Arterial BP synch c̄ pump - not heart
2:57	100		
2:58	110		
2:59	100		
3:00			- I.T. tube clamped
3:00.5	120		
3:01.5	140		- some resp. effort
3:02	140		
3:02½			- Resp effort 4/min

9-27-49 cont'd

3:03	125		
3:03.8	140		
3:04			- sample A_2
3:04.5	120	176	
3:07	120		- gas sample
3:08	120		
3:09			V. Temp 37°C - Art. 36.5°C
3.10			protamine sample
3:11	110	210	
3:12	120		
3:13	180		Dog Off venous side
3:13.2	200		
(25) 3:14			Dog off art. side
3:14.			I.T. tube unclamped
3:14¼	70		
3:15			Machine on A & V
3:15.3	80		
3:17	80		CO_2 tank empty
3:18.5	90		new CO_2 tank
3:21	110		
3:24	95		
3:26			A_3 sample
3:27			V_3 sample
3:27.3	80		Dog Off venous side
3:27.5	110		
3:27.6	80		
(39) 3:28			Dog Off both A & V
3:28.2	40		
3.28.5			I.T. tube out !!
3:31			Dog Dog

9-27-49 Data cont'd

On Blood

① Crossmatch

Dog A c̄ Op dog - ok
Dog B c̄ op dog ok
Dog A c̄ B ok

② Clotting times

Op. dog - 3 min
Donor dog A - 2 min
Donor dog B - 2 min

③ Heparin - Protamine Antagonism

A	0	2cc	α
B	20γ	"	21 min
C	30γ	"	2.5 "
D	40γ	"	2 "
E	50γ	"	2 "
F	60γ	"	2.5 "

④ Prothrombin times

Operative dog - 7 sec
Donor A - 10 sec
Resevoir - < 10 sec

⑤ Hematocrits

Resevoir 15
Resevoir (upper) 15
Operative dog
" " 15" - 28
" " 30" - 27

9-27-49 cont'd

⑥ Plasma Hgb

Donor blood - < 0.012 gms %
Operative dog - < 0.012 " "
Resevoir - 0.51 gms %
(this is an error)

5 min of perfusion - < 0.012
15 " " < 0.019
30 min " < 0.019

⑦ Gas from cylinders

85% O_2 - pyrogallic acid method

⑧ Blood Gas Analysis

	Van Slyke 20°	Corrected	%	Anticipated
A_1	44.4 + 44.8	10.594	90.03	11.645
A_2	46.0 + 46.8	11.015	92.36	11.926
A_3	42.0 + 43.2	10.073	96.29	10.564
V_1	29.4 + 28.6	6.87	5.87	11.645
V_2	22.6 + 21.8	5.22	5.27	11.926
V_3	14.6 + 14.0	3.394	3.32	10.564

			CC's/min
Hgb ≡ A_1	= 8.95 gms	A_1	- 55.0
Hgb ≡ A_2	= 8.9 gms	A_2	- 87.5
Hgb ≡ A_3	= 8.03 gms.	A_3	- 100.2

Conclusions

Entire procedure went well - dog died of asphyxia due to IT tube being out.

(32)

9-29-49

Purpose

To perfuse animal c̄ D-K machine & studying physiological effect in terms of plasma Hgb., hematocrit, prothrombin times, & oxygenation

Equipment

D-K machine
Air condition
45 ♂ mongrel

Conditions

RPM – arterial shaft – 50
venous " – 25
O_2 flow – 15 l/min + flooding
CO_2 " – 900 cc/min
Blood flow – 1600 cc/min
Anesthesia – pentobarbital
Heparin – Heparinum
Temperature – Venous 38.5°C
Arterial 38.0°C

Method

Cannulization of both femoral arteries, carotid artery & single catheter in right auricle

Data

On dog during perfusion

BP 160 on connecting manometer
BP dropped 120 after cannulation of right heart

Time	BP	Pulse	Remarks
2:18	105		Dog on
2:19	105		
2:20	70		
2:20.5	70		
2:21	70		
2:22	75		
2:22.5			100 cc trans.
2:23	80		
2:23.5	75		
2:25	90		
2:26			resp. efforts
2:28	90		
2:30	75		100 cc trans.
2:31	85		
2:32	80		
2:33	80		
2:35	75		Art. blood dark?
2:39	85		
2:40	65		
(27) 2:45			dog off
2:46			140 cc trans.
2:47.5	90		
2:48.5	120		

9-29-49
Data Cont'd

2:49.5 110
2:50 100

On Blood

① Crossmatch
Donor A c̄ Op dog ok
Donor B c̄ " ok
Donor A c̄ B ok

② Clotting times
Op. dog < 4 min
Donor dog A 2½"
Donor dog B 4 min
Postop dog -15" ∝

③ Heparin - Protamine Antagonism

Test tube	γ protamine	Blood	Clotting time
A	0	2cc	
B	20	"	
C	30	"	<50
D	40	"	<35
E	50	"	<4
F	60	"	<35

④ Prothrombin times
Donor dog A 7 sec
Donor dog B 7 sec
Operative Dog 5 sec.
Res. after mach 5 sec

⑤ Hematocrit
1. Reservoir before machine - not readable
2. " pre perfusion - " "
3. Operative dog preop - 37

9-29-49 cont'd

4. operative dog 15" 41
5. " " 30" 41

⑥ Plasma Hgb
Donor blood A } <0.120
Donor blood B }
Op. Dog pre perf <0.120
Reservoir pre perf <0.120
5' ∫ perfusion <0.120
15' ∫ perfusion <0.229
25' ∫ perfusion <0.154
90' post perfusion trap. 0.180
Machine 0.130
Transf 0.266

⑦ Gas from cylinders
Not done

⑧ Blood gas analysis (Karlson)

A_1 - 345
180.9 11.843 $\frac{11.843}{16.263}$ = 72.3%
130. Hgb = 12.1365
50.9

A_2 324.3
171.7 10.082 $\frac{10.082}{15.349}$ = 65.5%
129.4
42.3

V_1 315.0 A_1-V_1 = 3.657 vol %
165.0 8.186
130.4
34.6

V_2 331.1 A_2-V_2 = 3.727 vol %
155.0
131.1 6.355
36.9

9-29-49 contd

cc's blood introduced/min
592CC/min

Conclusions
Oxygenation not good. Reason not immediately evident. Copper jacket was flooded w O_2. Will check pH of blood.
Machine worked well.
Clotting time returned to normal in 2hrs.
340cc blood during procedure

Dog died 10:15 a.m. 9-30-49.
Autopsy: Moderate quantity of blood in chest. Moderate atelectasis of right upper lobe, mild atelectasis of right middle & lower lobes

First pH studies

(32)

10-1-49. Purpose
To again perfuse animal w/ D-K machine and to study:
plasma Hgb
prothrombin time
clotting time
Oxygenation
pH & CO_2 combining power.

Equipment
D-K machine
Air conditioned
44 lb mongrel ♂

Conditions
RPMs - arterial shaft - 20
Venous shaft - 18
O_2 flow - 15 l/min + continuous flooding of copper jacket
CO_2 flow - 900cc/min
Blood flow - 900cc/min
Anesthesia - pentobarbital
Heparin - heparmin
Temperature - 36°C Art - 36° Venous
cylinders - 4

Methods Cannulization of right carotid artery, both femoral arteries & azygos v. & inferior vena thru right auricle.

10-1 Data

On dog during perfusion

BP on cannulization carotid artery was 120, BP dropped to 4 on cannulization of azygos + auricle. Apparently cannula in inferior vena cava occluded it. BP rose momentarily to 100 before perfusion.

Time	BP	Pulse	Remarks
2:15	85		Dog on
2:17			flow 900 cc/min
5 2:20	60		
2:21			Cannulas changed from rt vent to inf. vena cava.
2:22			flow 700 cc/min
2:23			100 cc transf.
2:24			Clamp trachea
10 2:25	80		
2:26			small resp. motions
2:27	100		flow 1000 cc/min
15 2:30	80		trachea unclamped
2:31	60		no resp. efforts
2:34	40		100 cc transf
20 2:35	60		
25 2:40	50		
2:40.5	60		
2:43	65		

10-1 30	2:47	60	
	2:48		trachea clamped
	2:49		resp. efforts
35	2:49.5	80	resp. motions stop
	2:52	60	
40	2:54	70	60 cc transf.
	2:56		20 mgm heparin
45	3:00		Blood samples Hy.
	3:02	60	
50	3:08	50	
	3:09		100 cc transf
	3:11	60	
	3:12		100 cc transf
	3:13	70	
	3:15	70	100 cc transf
62 min	3:17	90	Dog on own
	3:20	80	
	3:21	70	
	3:24	60	
	3:38	60	250 cc blood
	↓		transf. 1c
	4:30	60+20	

Ool blood given during perfusion - 560
after perfusion - 250

10-1

On blood

① Crossmatch

Dog Donor A $\bar{c}$ op dog - ok
Dog " B c " - ok
Dog A $\bar{c}$ B - ok

② Clotting Times

Op dog 4.5 min
Donor A 15 "
Donor B 9
Postop - 45 min - 2 hrs.
3½ hrs - 8 min

③ Heparin - protamine antagonism

Test tube	Protamine	Blood	Clotting time
1	0	2cc	α
2	20	"	α
3	30	"	α
4	40	"	<12 min
5	50	"	<12 "
6	60	"	<20 "

④ Prothrombin times

Donor dog A - 20 sec
Donor dog B - 7 min
~~Operat.~~ dog - 5 min
Res. after mach - 6 sec
30 min post perf - clotted

⑤ Hematocrits

Reservoir, pre perf 12
Op dog 56
op dog - 20 min 58
Op dog - 30 min 56

10-1

⑥ Plasma Hgb

Reservoir <0.12
Dog (op) pre perf <0.12
5' perfusion <0.12
15' " <0.12
25' " <0.12
35' " <0.12
50' " 0.07105
30' post perfusion 15.5 = 100%

⑦ Hgb

at 5 min - 83.7 % 12.97 gms
at 15 min - 89.0 % 13.80 "
at 25 min - 86.8 % 13.45
Reservoir - 86.5 13.42
90 min post perf - 64.1

⑧ Gas Analysis
95% O_2

⑨ ~~Blood Gas~~ PH studies

Reservoir 6.98 → after mach - 7.34
Op dog 7.61
5' perfusion 7.30
10 7.16
15 7.17
20 7.16
25 7.19
30 7.15
35 7.17
40 7.07
55 7.18.

(10-1) (10) Blood Gas Studies Temp 31°C →

	A_1 - 283.8				
	173.6				
	133.4	Corrected CO_2 = 27.8 vols %	A_1	Anticipated O_2 = 16.254 V%	% oxygen sat = 58.3%
	O_2 40.2	Corrected O_2 = 9.479 vols %			
	A_2 - 326				
	191.1				
	143.0	Corrected CO_2 = 34.0 vols %	A_2	Anticipated O_2 = 17.292 V%	% oxygen sat = 65.5%
	O_2 48.1	Corrected O_2 = 11.342 vols %			
A_4 - 321.0	A_3 - 319				
185.8	186			Anticipated O_2 = 16.866 V%	% oxygen sat = 64.3%
137.6	141.2	Corrected CO_2 = 35.1 vols %	A_3		
O_2 48.2	O_2 45.8	Corrected O_2 = 10.799 vols %			
corrected - 11.342	V_1 - 314		A_4	Anticipated O_2 = 16.866 V%	% oxygen sat = 67.2%
corrected CO_2 = 34.1	156.2				
	132.4	Corrected CO_2 = 39.6 vols %	V_1	A_1-V_1 differance = 3.348 V%	CC's O_2 introduced 30.122
	O_2 23.8	Corrected O_2 = 5.612 vols %			
	V_2 - 310.2				
	157.8				
	131.8	Corrected CO_2 = 38.4 vols %	V_2	A_2-V_2 differance = 5.211 V%	CC's O_2 introduced -46.899
	O_2 26.0	Corrected O_2 = 6.131 vols %			
	V_3 - 307.2				
	154.8				
	139.0	Corrected CO_2 = 38.4 vols %	V_3	A_3-V_3 differance = 4.715 V%	CC's O_2 introduced 42.435
	O_2 25.8	Corrected O_2 = 6.084 vols %			
	V_4 - 298.0				
	155.2				
	130.2	Corrected CO_2 = 36.4 vols %	V_4	A_4-V_4 differance = 5.447 V%	CC's O_2 introduced 49.023
	O_2 25.0	Corrected O_2 = 5.895 vols %			

Conclusions

Again oxygenation "marginal". Dog obviously anoxic c̄ IT clamped. Dog on machine 1 hr 2 min. During this time BP averaged 60. Flow rate from vena cava was only 900 cc & could not maintain BP c̄ flow from arterial side.

It appears that following problems have been solved - hemolysis (+ c̄ lt, bleeding), mechanical defects of machine, temp. Problems yet to be solved. Oxygenation + cannulization of vessels.

Dog dead in a. m.

Autopsy

Chest full of blood c̄ resultant atelectasis. Abdominal cavity grossly normal

(33)

10-4-49 Purpose

To again perfuse animal c̄ D-K machine & cannulated by inf. V.C. thru "T" tube & cannula in azygos v.

Equipment

D-K machine

54 lb mongrel ♂

Conditions

RPMs - arterial shaft 50

" - venous shaft 20

O_2 flow - 15 l - min + flooding

CO_2 flow - 900 cc/min

Blood flow - 1300 cc

Anesthesia - pentobarbital

Heparin - heparamin

Temperature - Art 39°

Ven 39°

cylinders - 5

Method

Perfusion via both femoral arteries. Blood withdrawn thru "T" tube in inferior cava & thru cannulated azygos vein. Vena cava occluded as noted in chronological report in "Data".

10-4-49 cont'd

Data

(A) On dog during Perfusion

	Time	BP	Pulse	Remarks
0	2:17	120		Dog on machine
5	2:22	90		Venous pump slowed
8	2:25	90	140	CO_2 off ~~Oxygenator stop~~
10	2:26.5	70		Venous pumps slowed
11	2:28	70		transfusion
13	2:30	70	140	Flow rate - 1300 cc
15	2:32.5	65		Trans 100 cc
18	2:35	70	144	
20	2:37			Ven. press 6.5 cm
21	2:38	60		
22	2:39	70		
25	2:42	70		
28	2:45	75	144	Ven. press 6.5 cm
29	2:46	50		
30	2:47			Venous side off
30½	2:47.5			150 cc trans
~~30 min~~ 31	2:48	100	144	Art side off
35	2:52	70	124	
38	2:55	95		
9 *	2:55.3	100	133	200 cc IV trans
				V.P 12 cm
12	3:00			40 mgms protamine
17	3:05	115		25 mgm "
20	3:08	120		V.P. 13 cm

10-4-49 cont'd

total trans - during perf - 350 cc
after perf - 500 cc

(B) On Blood

① Crossmatch
Donor Dog A c̄ B — ok
Donor A c̄ op dog — ok
Donor B c̄ op dog — ok.

② Clotting times
Operative time — 5 min
Donor A — 14 min
Donor B — 10 min
Post perf 30 min — 14 min

③ Heparin - protamine Antagonism

Test tube	γ Protamine	Blood	Clotting time
1	0	2 cc	
2	20	↓	5 min
3	30		10 "
4	40		10 "
5	50		10 "
6	60		10 "

④ Prothrombin times
Reservoir — 6 sec
Reservoir 2 — 10 sec
Op dog — 5 sec
30 min post perf — 3 sec.

⑤ Hematocrit
Reservoir — 16
Reservoir after machine — 17
Op dog — 39

(over)

(5) Hematocrits (cont'd)

15 min perf – 37

Post perf – not readable.

(6) Plasma Hgb –

Reservoir – before mach	– <0.120 gm-%
Reservoir – after mach	– <0.120 "
Operative dog	– <0.120 "
5' perfusion	– <0.120
15' "	– <0.120
25' "	– <0.120
30' "	– <0.120
90' "	– <0.120
Reservoir post perf.	– <0.120

(7) Hgbs

A_1 (5 min)	– 65.6%
A_2 (15 min)	80.0%
A_3 25 min	62.4%
A_4	not done

(8) Gas Analyses

Not done

(9) PH studies

Reservoir –	7.04
Op dog	– 7.34
5' –	– 7.15
10 –	7.16
15 –	7.18
20 –	7.19
25 –	7.19
30	Dog off

(10) Blood Gas Analysis

A_1 – 305.4
171.0 CO_2 134.4
117.2
O_2 (53.8) 12.68 corrected vols %

A_2 – 344.8
172.0 CO_2 172.8
117.2
O_2 (54.8) 12.82 corrected vols %

A_3 – 315.6
173.0 CO_2 142.6
117.8
O_2 (55.2) 13.02 corrected vols %

V_1 – 316.8
143.8 CO_2 173.0
117.2
O_2 (26.6) 6.27 corrected vols %

V_2 – 286.4
127.0 CO_2 159.4
115.0
O_2 (12.0) 2.83 corrected vols %

V_3 – 290.0
126.0 CO_2 164.0
115.0
O_2 (11.0) 2.59 corrected vols %

(over)

10-4-49 cont'd

	Anticipated	Actual	% oxygenation
A_1 -	13.74	12.68	92.2%
A_2 -	15.54	12.82	82.4%
A_3 -	12.12	13.02	93.0%

			cc's O_2/min
$A_1 - V_1$	= 6.41 vols%	x 13.0 =	83.33
$A_2 - V_2$	= 9.99 vols%	x 13.0 =	129.87
$A_3 - V_3$	= = 10.43 vols%	x	135.59

CO_2 combing power
5' perfusion 28 vols%
15 perfusion - 25 vols%

Conclusions

Dog died during attempt to repair vena cava.
Entire procedure satisfactory except for closure of vena cava.
Should have pH's on venous side.

34

10-6-49 Purpose

To again perfuse animal c̄ D-K machine + to attempt to do cardiac surgery

Equipment

D-K machine
Air conditioned
37 lb ♀ - previously has had 2 tracheal resections + unknown abdominal surgery

Conditions

RPM's - arterial shaft - 50
venous shaft - 24
O_2 flow - 15000 cc/min + flooding
CO_2 flow - 900 cc/min
See op. notes
Blood flow - 1000 cc/min
Anesthesia - pentobarbital Na
Heparin - liquaemin
Temperature - art - 37.5
Ven - 38
Box - 39
cylinders - 4

Method

Cannulization of both femoral arteries, right auricular appendage + right carotid.

Data

(A) On dog during perfusion

Time	BP	Pulse	Remarks
4:03	0	Fibrillating	Dog on
4:04	20		
4:04:5	20		Oxygenation poor
4:10	20		Flow 1000 cc
4:13	20		Dog dead - off mach

(B) On Blood

(1) Crossmatch

Donor$_1$ c̄ Donor$_2$ - ok
D_1 c̄ O = ok
D_2 c̄ O = ok
D_3 c̄ O - ok
D_1 c̄ D_3 - ok
D_2 - D_3 - ok

(2) Clotting times.

D_1 - 30 sec
D_2 - 5 min
Op dog - 10 min
D_3 - 6 min

(3) Heparin - Protamine Antagonism

Tube Protamine Blood Clotting time

Not done
Dog dead

(4) Prothrombin times

Reservoir - preperf - 10 sec
Op dog - 15 min pot perf
not done

(5) Hematocrits

Operative dog - 36
Reservoir preperf - 32

(6) Plasma Hgb

Reservoir - <0.12
Op dog <0.12
5' perfusion - <0.12

(7) Hgbs

8.7 gams A_1

(8) Gas analysis

Not done

(9) pH studies

	Arterial	Venous
Op. dog	7.43	
5' perfusion	7.26	7.09
	7.26	

(10) Blood Gas Analysis

A_1 41.8 x .237 = 9.91
V_1 5.6 x .237 = 1.33
$A_1 - V_1$ = 8.58
flow 8.58 x 10 = 85.8 cc/min

(11) CO_2 Combining Power

A_1 = 22.8 vol %
V_1 = 14.6 vol %

10-6-cont'd

Conclusions

Dog previously had had 3 major surgical procedures. Considerable difficulty was experienced in ETT tube & atelectasis. There was great delay & dog was near dead & beginning of perfusion

35

Bleeder

10-10-49

Purpose

To again perfuse animal in D-K machine and attempt to do cardiac surgery.

Equipment

D-K machine air conditioned
34 lb ♂ mongrel.

Conditions

RPMs - arterial shaft - 50
Venous shaft - 25
O_2 flow 15 l/min + flooding
CO_2 flow - see record
Blood flow - see "
Anesthesia - pentobarbital Na
Heparin - Heparamin
Temperature - Art - 38°C
Ven - 38.5°C
Body - 39°C

Method

Cannulization of both femoral arteries, right atrium appendage & right carotid artery.

over

10-10-49 Contd

Data

(A) On dog during perfusion

	Time	B.P.	Pulse	Remarks
	1:55	100	140	~~Tip in vena cava~~
0	1:56	100		Dog on
0.5	1:56.5	60		
1	1:56.8	80		NO CO_2
1.5	1:57.5	75		
2	1:58	40		Flow rate 1150
3	1:59			100 cc transf
3.5	1:59.5	50		
5	2:01.5	40	120	Flow rate 1000 cc
7 8	2:03	40		
8 9	2:04			100 cc transf
8 5 8	2:04.5	60		
9 10	2:05	65		
10 10'	2:06	70		
11	2:07	75		
12	2:08	60		Flow rate 1100 cc
13	2:08.5	75		100 cc transf
1'	~~2:09.5~~	~~70~~		
14	2:10	80		
15 15'	2:11	70	160	
16	2:12.5	60		
17	2:13	60		
18	2:14	60		
19	2:15	65		
20 20'	2:17	60		
22	2:18	65		
23	2:19	65		

25'	2:20	70	~~160~~
25	2:21	65	Flow rate 1300 cc
26	2:22	65	
27	2:23	60	
28	2:24	60	
29	2:25	60	
30'	2:26	60	Dog off venous side
	~~2:26.1~~	~~70~~	
31	2:26.2	80	
	~~2:26.5~~	~~100~~	
30.5	2:26.6	100	152 Dog off art.
1	2:27.5	80	
22	2:48	100	500 cc iv transf
34	3:00	80	200 cc saline
74	3:40	80	500 cc WB IV
240	6:30		another 500 cc W.B. added

(B) On Blood

(1) Crossmatch

$D - D_2$
$D_1 - D_3$
$D_2 - D_3$
$D_1 - O$
$D_2 - O$
$D_3 - O$
} ok

(2) Clotting times

D_1 = 6 min D_2 = 7 min Op dog = 3 min
Post perf. 76 min – 70 min
12.1 min – 25 min
5 hrs – 7 min

③ Heparin - Protamine Antagonism see ⑫ also
At 2:25 p.m.

Test Tube	Protamine	Blood	Clotting time
1	0	2cc	∞
2	20	↓	∞
3	30	↓	10 min
4	40	↓	10 "
5	50	↓	10 "
6	60	↓	10 "

Dog gram 6cc protamine at 2:45 p.m.

④ Prothrombin times
Reservoir preper - 6 sec
Operative dog - 7 sec
5 min perf - 3 sec
45 min post perf - 10 sec

⑤ Hematocrit
Op. dog - 42.5
Reservoir preper - 21.0
16.0 after machine
15' min perf. 36.5
30 " perf 35.5
30 " post perf 35
100 " post perf 48

⑥ Plasma Hgb
Reservoir - before mach - <0.120 gm %
Reservoir " after mach " <0.120 " "
Operative dog - <0.120 " "
5' perfusion <0.120
15' perfusion <0.120
25' " " <0.120
45 post perf <0.120
100 <0.120
Postperfusion - 7:40 p.m. <0.086

⑦ Hemoglobin
A_1 - 75.4
A_2 80.9
A_3 - 82.7

⑧ Gas Analysis
Not done

⑨ pH studies

	Art	Ven
Reservoir -	7.45	
Operative dog -	7.37	
5' perfusion	7.46	7.34
10' perfusion	7.30	7.27
15' perfusion	7.28	7.24
20' perfusion	7.28	7.22
25' " "	7.29	7.22
30 " "	7.28	7.22

⑩ Blood Gas Analysis
A_1 - 13.22 corrected / 14.65 anticipated } 96.9% saturation
A_2 - 8.48 corrected / 15.70 anticipated } 54%
A_3 8.34 corrected / 16.0 anticipated } 52.1%
V_1 9.1 CC o mm = 45.32
V_2 5.96 " = 37.76
V_3 5.92 " = 31.46

(11) CO_2 Combing power
at 5' = 39.42 Vols %
at 25' = 23.46 Vols %
Op. tag = 41.17 Vols %

(12) Protamine - Heparin Analogonism
at 5:10 pm

Tube	Protamine	Blood	Clotting time
1	0	2 cc	20 min
2	20	↓	3 "
3	30		3.5 "
4	40		4 "
5	50		4.5 "
6	60		4.5 min

30 mgm protamine at 5:21 pm

Conclusions

All went well - except oxygenation
Dog is acidotic!
Dog had bloody stool post operative - dog died at 9:15 a.m 10-11-49

Autopsy

Typical hemolysis - bleeding syndrome.

Sections taken - Dog #4

Post mortem data -
pl. Hgb = 0.163 gm %
Hematocrit - 70
clotting times - 9 min
BUN 26 mgm %