3 Donor Procurement Operation in Donation After Circulatory Death Donors

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Outcomes for liver transplantation with the use of donation after circulatory death (DCD) donors have largely been influenced by the donor operation. Coordination with the staff from the organ procurement organization (OPO) as well as the hospital staff is critical for a successful outcome. As often the first contact with organ transplantation for many of the hospital staff, donor surgeons should view themselves as ambassadors of transplantation. The transplant surgical team can best support the donation process by [1] arriving to the donor hospital ahead of the scheduled time, [2] making introduction and reviewing the surgical recovery process with the OR staff, [3] communicating special needs for procurement, and [4] maintaining professional conduct in the OR and talking supportively about organ and tissue donation. The transplant centers rely heavily on a good partnership between the OPO and the donor hospitals – a Centers for Medicare and Medicaid Services (CMS) contractual requirement to permit clinical evaluation by the OPO for donation potential. The OPO provides donation education to the hospital, assists with hospital in crafting their DCD policy modelled after American Society of Transplant Surgeons (ASTS) guidelines, and provides family support to donor families. Adjunct to this partnership, it would be recommended that all parties (OPO staff, operating room nurses, technicians and assistants, respiratory therapists, ICU nurses, observers, and if possible withdrawing physicians) meet to discuss the details of the donation process in the manner of a "huddle." The goals of this huddle are as follows:

1. To provide an opportunity for introductions. As ambassadors of transplantation, the donor surgeon is responsible for articulating the uniqueness of DCD in perspective with more controlled donor operations involving brain-dead donors (DBD).

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2. To provide an opportunity to humanize the gift of life through organ donation. Thank all participants in the process on behalf of the transplant center but also importantly the recipients of the organs. Highlight the donor and donor family wishes to proceed with organ donation despite not meeting brain death criteria – an amazing gift in the setting of a very difficult time for the donor family.
3. As speed of cold perfusion of organs is critically important in the DCD organ recovery operation and hospital polices as well as staff interpretation of hospital policies may be in disagreement; it is important to clarify key questions to the donation process with all parties involved(these would include, but not exclusively):
   (a) Where is the withdrawal going to happen? In the OR vs. PACU vs. ICU? What is the distance from ICU to OR?
   (b) Will the donor be placed on a stretcher vs. ICU bed vs. OR table?
   (c) When will heparin be given?
   (d) How long is the hospital policy's "hands-off/mandatory wait time" period?
   (e) Will the donor be allowed to be transported during the "hands-off/mandatory wait time" period?
   (f) Who will assist during the transport of the donor, and will it be necessary to clear the rails from the stretcher or hospital bed or removing the IV pole attached to bed or stretcher?
   (g) How are vitals going to be monitored, and how is asystole or electromechanical dissociation (PEA) going to be defined and identified? How will asystole or PEA be confirmed?
   (h) How is communication going to take place between the donor surgical team and the OPO staff monitoring the withdrawal?
   (i) Who will communicate when incision can be made? Assigning, a priori, one responsible OPO staff member allows for clarity of the donation process.
   (j) When can the patient be prepped and draped?
   (k) Who will be responsible for assisting the family, if they are present, during the withdrawal?

Having buy-in from the hospital staff as well as the OPO members is critical for a smooth and successful donor operation. Speed and timing has long been considered a key component to the donor operation. Casavilla et al. provided us the earliest description of the "super-rapid" technique for organ retrieval [1]. Subsequently, many reports revealed that extended donor warm ischemia time (DWIT) presented a critical risk factor for post-liver transplant graft failure and poor outcomes – most critically the ischemic-type biliary strictures (ITBS) [2–5]. Using a more granular approach to the time intervals during the withdrawal, the Mayo Clinic Florida group identified the asystole-to-cross-clamp time interval as critical to avoiding ITBS, and they recommend avoiding donors in whom this time interval exceeds 10 minutes [6, 7]. With this in mind, this highlights ever more the need for clear and close coordination with the donor procedure leading up to the incision as well as from incision to cross-clamp. A DCD time sheet can be seen in Appendix 3.1.

In 1995, the first description of the "super-rapid technique" is as follows:

> After a midline incision from the xiphoid process to the symphysis pubis, the distal aorta was cannulated, and perfusion of the organs with cold preservation solution started. Perfusion was routinely initiated less than 4 min after skin incision. Next, the sternum was split, the thoracic aorta was cross-clamped, and the intrapericardial inferior vena cava was vented to decompress the organs. The inferior mesenteric vein was then cannulated to perfuse the portal system, and the abdominal cavity was filled with ice slush. In adults, approximately 2 L of cold preservation solution (Viaspan) was infused into both the portal and the systemic arterial systems. Once the liver became palpably cold and free of blood, hepatectomy, followed by en bloc nephrectomies, was performed expeditiously [1].

Essentially the donor operation has changed very little; however, more recent experiences have demonstrated that perfusion can be initiated within 1 minute after skin incision. This is accomplished by the following detailed steps:

Preparation of the Room

1. Prepare the cannulas or tubing with tubing preflushed.
2. Assign all team members an initial role. Whether prepping and draping is necessary, coordinate each member a task in the initial period.
3. Prepare the Mayo stand, accommodating only the necessary instruments to avoid unintentional injury to team members or disruption. It is our preference to have only the following: two large blades (preferably 20 blades) on regular knife handles, a pair of curved Mayo scissors, a pair of Metzenbaum scissors, and two large 6-inch Kelly hemostatic forceps. Have available the sternal saw and sternal retractor and if available the large Balfour retractor (not shown) (Fig. 3.1).
4. At a minimum, three suction tubes should be attached to a large fluid waste management system.

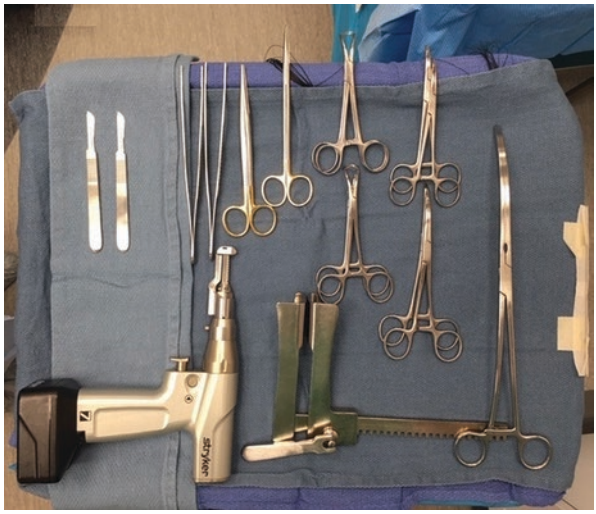

Fig. 3.1 Mayo stand showing instruments for DCD procurement

Cannulation to Cross-Clamp

5. Rapid skin incision, focused primarily periumbilically and extended toward the pubic symphysis (the target is the retroperitoneal aorta at the level of the iliac bifurcation).
   (a) If the patient has had a prior laparotomy, great care should be made to take down adhesions and avoid enterotomy.
6. Immediate evisceration of primarily the small bowel to gain exposure to the retroperitoneal aorta.
7. Sharply incise the colonic mesentery and tissue overlying the abdominal aorta.
8. Blunt dissection and encircling of the aorta with the left index finger (Fig. 3.2).
9. Incision of the aorta at the crotch of the bifurcation of the left and right iliac arteries.
10. Insertion of preflushed four-lead arthroscopic irrigation set tubing. This particular tubing has a white tapered tip to allow for easy cannulation. A large-bore cannula can be used to insert into the aorta; however, the preference for the tubing directly is to reduce the amount of resistance for flow of the flush.
11. Secure cannula with a curved Kelly hemostatic forceps or Kocher clamp.
12. Begin flush.
13. Extend midline incision cephalad to include sternotomy. Open the left chest pleura with assistant pulling on the sternum toward the ceiling.
14. Eviscerate or push the left lung cephalad to gain exposure to the thoracic descending aorta.
15. Cross-clamp using DeBakey aortic clamp:

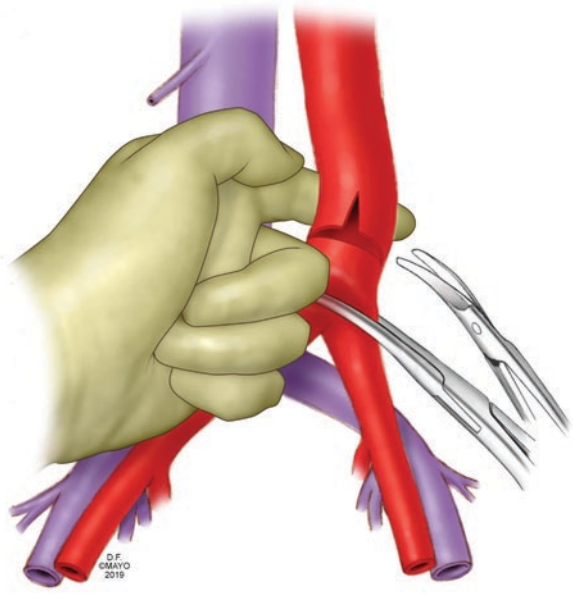

Fig. 3.2 Distal aorta immediately prior to cannulation. (Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved)

(a) Special consideration regarding aortic access in the setting of prior sternotomy:
  (i) This can be performed through the diaphragm by incising the diaphragm along the left costal margin. The assistant will need to expose the chest cavity by retracting the ribcage toward the ceiling. By medially rotating the lung, the aorta along the spine can be exposed for cross-clamping.
  (ii) If transthoracic access to the aorta is preferred, access to the left chest can also be performed by transecting the left ribs all along the sternum to avoid the sternal wires and still gain access to the left chest.
  (iii) Cross-clamp abdominal aorta just below the diaphragm by releasing left triangular ligament of the liver and excising diaphragm crus. Special attention will be needed in this area not to injure a replaced left hepatic artery (if present).

16. Open pericardium.
17. Vent the suprahepatic Inferior vena cava (IVC) by incising the caval atrial junction; alternatively the lower IVC can be incised to vent with insertion of the pool-tip suction cannula to drain the effluent.
18. Open the right pleura to allow for decompression of effluent and blood into the right chest.
19. Pack the right chest and abdomen with ice.

Portal and Gallbladder Flush

20. In situ portal flush of the liver can be accomplished by cannulation of either the superior mesenteric vein (SMV) or the inferior mesenteric vein (IMV).
  (a) SMV cannulation:
    (i) Gain exposure to the SMV by having the assistant grab the transverse colon with his/her right hand and splaying out the mesenteric root by retracting the small bowel and mesentery with his/her left hand.
    (ii) Incise peritoneum of the mesentery, and carefully dissect through lymphatic and fat tissue toward the SMV, taking care not to disrupt any blood vessels.
    (iii) Encircle the SMV usually at the branch points of the ileocolic and right colic veins.
    (iv) Cannulate SMV with preflushed two-lead irrigation set tubing with the same tapered end.
  (b) IMV cannulation:
    (i) The IMV can be found at the ligament of Treitz with cephalad retraction of the bowel.
    (ii) With care, dissect the vein from the surrounding mesenteric tissue.
    (iii) Encircle the IMV and cannulate with typically a 10 F cannula.
    (iv) The cannula is best secured using 2-0 silk suture.

21. Target flush for 4 L aortic and 2 L portal flush.
22. Incise gallbladder, and flush with cold saline irrigation in bulb syringe under pressure to clear the bile duct.

Mobilization of the Liver and Hepatectomy

23. Take down the diaphragmatic attachments to the left lateral segment.
24. Incise the gastrohepatic ligament with care to identify a potentially replaced left hepatic artery; in many cases, the left hepatic artery may be difficult to appreciate. To be safe, taking the left gastric artery widely along the lesser curvature can ensure preservation of a replaced left hepatic artery.
25. Once flush is complete, perform hepatectomy beginning in the hilum. With the assistant retracting the duodenum with his/her left hand, begin dissection superficially taking all the omental fat around the porta hepatis.
26. Identify the hepatic artery lymph node, and trace dissection toward the pancreas to identify the gastroduodenal artery (GDA).
27. Divide the GDA.
28. Then trace GDA toward common hepatic artery, gaining exposure of the portal vein.
29. Identify the splenic artery and divide.
30. Identify and divide the common bile duct.
31. With care, divide all the neurolymphatic tissues between the bile duct and portal vein, being cautious to identify a potentially replaced right hepatic artery.
32. If a right hepatic artery is noted, trace this structure into the pancreas toward the superior mesenteric artery (SMA)
33. With the pancreas and mesentery retracted caudally, divide the SMA with at least 4–8 cm of length to ensure that the replaced right hepatic artery with its origin on the SMA is preserved (usually found within 2 cm of the SMA origin off the aorta).
34. Once the SMA has been identified distally, trace the SMA toward its origin off the aorta.
35. Amputate the SMA flush with the aorta in order to preserve the branches of the renal arteries, which often insert at the level of the SMA. Preserve a small lip of the aorta cephalad to allow for extension of the aortic patch toward the celiac artery.
36. Transect the aorta at the level of the celiac artery.
37. Trace the aorta cephalad and complete the transection of the aorta supraceliac.
38. Divide all the diaphragmatic attachments between the aorta and the retrohepatic and infrahepatic IVC.
39. Complete the transection of the IVC-atrial junction within the pericardium.
40. Identify the suprahepatic IVC in the chest, and incise all the pericardial and diaphragmatic attachments around the suprahepatic IVC.
41. Completely mobilize the liver from its diaphragmatic attachments, with care not to tear the liver capsule.
42. Identify the right adrenal gland and bisect the gland.

43. Divide the infrahepatic IVC with care to preserve the right renal vein with a suitable IVC cuff as well as retaining the right adrenal vein on the retrohepatic IVC.
44. Complete hepatectomy.

Backtable Flush

45. Once removed, perform a backtable flush of the liver by cannulating the celiac artery with 10 F cannula. This can be secured with a silk tied around the celiac origin. If there is a replaced right hepatic artery, separate cannulation of the SMA will be necessary to flush the right hepatic artery as well.
46. With great care, use hemostatic clamps to clamp the splenic artery, GDA, and branches of the left gastric to prevent loss of flush.
47. Flush the liver through the artery on the backtable until effluent coming from the suprahepatic IVC is devoid of any evidence of blood; this may require another 2–4 liters of flush (Fig. 3.3).
48. Package the liver.

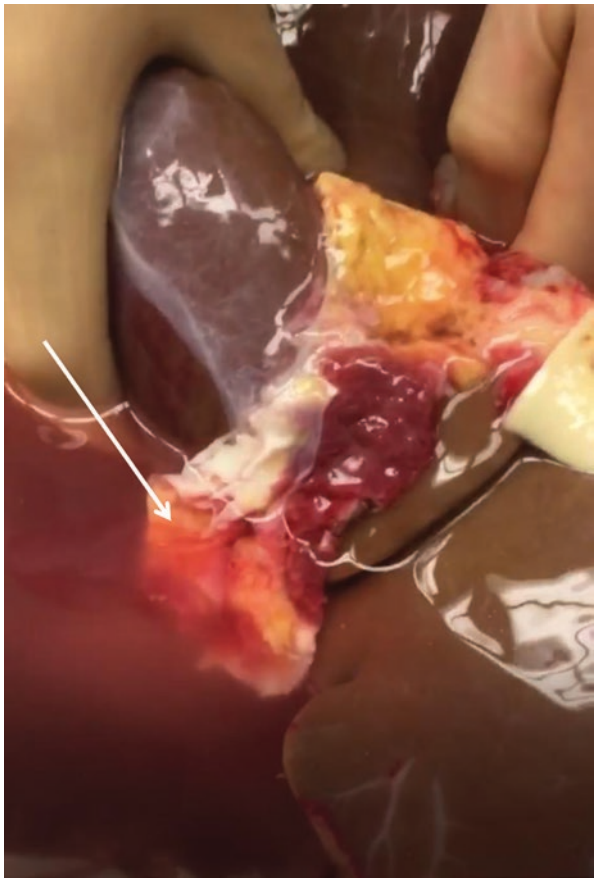

Fig. 3.3 Backtable flush of the liver. Flush until the effluent coming from the suprahepatic IVC is devoid of blood

Prior to accepting the liver for transplantation, it is critical for the donor surgeon to scrutinize the donor withdrawal flowsheet to confirm acceptable ischemic times based on hemodynamic parameters. In particular, we stress asystole-to-cross-clamp time of less than 10 minutes. An example flowsheet (Fig. 3.2) highlights the dangers of using only DWIT or incision to cross-clamp as markers for a successful donor operation. Despite a DWIT of only 47 minutes and an incision to cross-clamp at 2 minutes, the period of PEA was likely an additional 13 minutes, resulting in a total asystole-to-cross-clamp time of 17 minutes. This donor was inevitably declined in the operating room.

PEA is an area of greatest controversy. As defined by the Advanced Trauma Life Support (ATLS), PEA is defined as an organized rhythm without a palpable pulse. The definition of PEA can be further differentiated into pseudo-PEA and true PEA [8]. Pseudo-PEA is a profound state of cardiogenic shock that is inadequate to maintain perfusion pressure (a nondetectable pulse). According to ATLS guidelines, palpable pulses are lost in the carotid, femoral, and radial artery when the systolic blood pressure is less than 60 mmHg. This may correlate with some centers' definition of functional donor warm ischemia time (fDWIT) which will be discussed elsewhere in this book. True PEA represents a true uncoupling of cardiac mechanical activity from cardiac electrical activity and a complete absence of mechanical contractions. While it is paramount to not interfere with the withdrawing physicians' definition of cardiac death (either asystole or PEA), knowing what level of risk the transplant surgeon/center is willing to take must be clearly defined. Physiologically, the difference between pseudo-PEA and true PEA for the liver is likely minimal, and caution should be taken for organs from donors who endure prolonged periods of poor perfusion (Fig. 3.4).

In summary, the donor operation rests upon a clear cooperation of the donor hospital staff, OPO staff, and donor surgical team to allow for a smooth and efficient procurement that accomplishes an expedient asystole-to-cross-clamp interval of less than 10 minutes and suitable flush of the liver. With these goals in mind, a successful outcome for all parties (the donor hospital staff, the OPO, the transplant team, and most importantly the transplant recipient) can be accomplished.

DCD FLOWSHEET

PRE-OPERATIVE MANAGEMENT

Was patient extubated? Yes

Heparin: ☑ **Dosage:** 30000 units **Time:** 14:22

Withdrawal Date-Time: 04/25/2019 14:27 CDT

Agonal phase start Date-Time: 04/25/2019 14:29 CDT

Observation period start Date-Time: 04/25/2019 15:09 CDT

Pronouncement of death Date-Time: 04/25/2019 15:09 CDT

1st authorized clinician declaring death:

2nd authorized clinician declaring death: .....

Enter OR Date-Time: 04/25/2019 15:11 CDT

Surgical team separate from the donor during withdrawal and death declaration? Yes

OR time-out Date-Time: 04/25/2019 15:12 CDT

Incision Date-Time: 04/25/2019 15:12 CDT

Start of flush/cooling (cross-clamp) Date-Time: 04/25/2019 15:14 CDT

Exit OR Date-Time: 04/25/2019 18:10 CDT

Target an incision to crossclamp time within 2-3 minutes to allow for a total asystole to crossclamp time within 10 minutes.

Warm ischemic time (agonal to initiation of flush/cooling): 45 mins

Last hour urine output: 0 ml **Total urine output in OR:** 0 ml **Average urine:** ml/hr

Any Extracorporeal Support Given (ECMO, etc.): No

HEMODYNAMIC MEASUREMENTS (MINIMUM OF Q5 MIN)

	0 min (14:27)	1 min (14:28)	2 min (14:29)	3 min (14:30)	4 min (14:31)	5 min (14:32)	6 min (14:33)	7 min (14:34)	8 min (14:35)	9 min (14:36)
HR	155	82	60	62	72	67	39	89	68	69
BP	120 / 70	209 / 109	199 / 87	202 / 92	168 / 98	150 / 101	114 / 57	147 / 69	110 /43	110 / 53
MAP	87	142	124	129	121	117	76	95	65	75
RR	24	25	13	0	9	8	0	0	28	27
SaO2	99	82	22	0	0	0	0	0	0	0
	10 min (14:37)	11 min (14:38)	12 min (14:39)	13 min (14:40)	14 min (14:41)	15 min (14:42)	16 min (14:43)	17 min (14:44)	18 min (14:45)	19 min (14:46)
HR	89	89	90	97	102	102	104	103	107	99
BP	169 / 73	228 / 93	243 / 100	237 / 99	214 / 94	196 / 94	186 / 89	184 / 85	178 / 79	179 / 83
MAP	105	138	148	145	134	128	121	118	112	115
RR	28	28	22	22	29	29	30	30	26	34
SaO2	37	35	40	39	36	30	31	31	28	28
	20 min (14:37)	21 min (14:48)	22 min (14:49)	23 min (14:50)	24 min (14:51)	25 min (14:52)	26 min (14:53)	27 min (14:54)	28 min (14:55)	29 min (14:56)
HR	105	97	102	104	96	96	96	96	93	71
BP	175 / 81	172 / 79	155 / 72	139 / 68	139 / 66	145 / 66	147 / 66	135 / 63	141 / 64	64 / 32
MAP	112	110	100	92	90	92	93	87	90	43
RR	25	33	28	20	28	32	29	28	20	11
SaO2	32	22	23	20	15	21	18	16	8	0
	30 min (14:57)	31 min (14:58)	32 min (14:59)	33 min (15:00)	34 min (15:01)	35 min (15:02)	36 min (15:03)	37 min (15:04)	38 min (15:05)	39 min (15:06)
HR	29	33	36	40	39	36	38	33	30	23
BP	0 / 0	26 / 18	24 / 15	22 / 14	19 / 14	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
MAP	0	21	18	17	16	0	0	0	0	0
RR	11	7	7	8	7	6	6	0	0	0
SaO2	0	0	7	42	0	0	0	0	0	0
	40 min (15:07)	41 min (15:08)	42 min (15:09)	43 min (15:10)	44 min (15:11)	45 min (15:12)	46 min (15:13)	47 min (15:14)	48 min (15:15)	49 min (15:16)
HR	18	0	0	0	–	–	–	–	–	–
BP	0 / 0	0 / 0	0 / 0	0 / 0				– / –	– / –	– / –
MAP	0	0	0	0				–	–	–
RR	0	0	0	0				–	–	–
SaO2	0	0	0	0	–	–	–	–	–	–
	50 min (15:17)	51 min (15:18)	52 min (15:19)	53 min (15:20)	54 min (15:21)	55 min (15:22)	56 min (15:23)	57 min (15:24)	58 min (15:25)	59 min (15:26)
HR	–	–	–	–	–	–	–	–	–	–
BP	– / –	– / –	– / –	– / –	– / –	– / –	– / –	– / –	– / –	– / –
MAP	–	–	–	–	–	–	–	–	–	–
RR	–	–	–	–	–	–	–	–	–	–
SaO2	–	–	–	–	–	–	–	–	–	–

Likely unrecognized PEA

Fig. 3.4 Donor withdrawal sheet showing vitals. Caution should be taken in utilizing livers when prolonged periods of PEA are observed

Appendix 3.1: Donation After Circulatory Death Withdrawal Sheet

Time of Extubation/Withdrawal:_____ Location of Withdrawal: OR / ICU/ Other_____

Heparin given: before withdrawal / after withdrawal Dosage:_____ Time: _____

Time when sBP < 50mmHg:_____ Time when PEA:_____

Time when SpO2 < 80%: _____

Mandatory wait time: _____ Time of Death:_____

- Incision time:_____
- Aortic Cannulation time:_____
- Initiation of flush time: _____
- Cross Clamp time:_____
- Portal Vein Cannulation time:_____

Aortic Flush Volume:_____liters Portal Flush Volume:_____liters

Back Table Flush: Yes / No _____liters used

Flush Quality: _____

Time	Blood Pressure	Pulse Rate	O2 Saturation	Notes
Initial				
Time	B/P	Pulse	O2	Notes
@ 1 min				
@ 2 min				
@ 3 min				
@ 4 min				
@ 5 min				
@ 6 min				
@ 7 min				
@ 8 min				
@ 9 min				
@ 10 min				
@ 11 min				
@ 12 min				
@ 13 min				
@ 14 min				
@ 15 min				
@ 16 min				
@ 17 min				
@ 18 min				

Time	B/P	Pulse	O2	Notes
@ 19 min				
@ 20 min				
@ 21 min				
@ 22 min				
@ 23 min				
@ 24 min				
@ 25 min				
@ 26 min				
@ 27 min				
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@ 60 min				

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