

Technical Note

How much is red blood cell fragmentation increased by the use of closed luer lock access devices on catheter hubs?

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tion during dialysis with different types of closed luer lock access devices on the catheter hubs.

Introduction

The opening and manipulation of central venous (CV) catheters before and after each dialysis event might result in catheter-related blood stream infections [1–3]. In order to reduce those infection risks, different types of closed luer lock access devices are commercially available.

Such connectors are placed on the arterial and venous catheter hub and are designed with a split septum of medical grade silicon such that they can stay safely in place during the interdialytic period as well as during dialysis.

Besides the proven microbiological efficacy in infection reduction and/or elimination [4–6], those types of connectors are designed to apply with blood flows up to 600 mL/min during dialysis and to create an unobstructed fluid path in the open position, with an equivalent resistance compared to a direct connection of male and female luer. Although those closed luer lock access devices do not contain mechanical valves that could cause haemolysis, no data are known on whether the split septum fully opens and does not exert any additional resistances to the blood flow.

Since no data were known on these resistances, we previously investigated *in vitro* the flow resistance through three different closed luer lock access devices [7]: BD Q-Syte™ (Beckton-Dickinson, USA), second edition Tego™ (ICU Medical, USA) and Swan Lock connector (Codan, Germany) (Figure 1). This *in vitro* study revealed that pressure drops over the three connector types were attributable to the position and opening system of the silicon split septum. Additional resistances to blood flow were minimal in the Tego™ and Codan connectors, while they were significant in BD Q-Syte™.

In order to assess whether those resistances are in the safe range or not, the present clinical study was set up to study the absence or incidence of red blood cell fragmenta-

Patients and methods

The study included 16 stable haemodialysis patients (12 women and 4 men) without residual renal function. The study was approved by the local ethical committee, and informed consent was obtained from the patients. The patients were 76 ± 11 years old and had spent 22 ± 13 months on dialysis. Conventional haemodialysis was performed during 4 hours with FX8 (Fresenius Medical Care, Germany) ($n = 10$), Sureflux 210GA (Nipro, Japan) ($n = 4$) and BLS517SD (Bellco, Italy) ($n = 2$) dialyzers. As vascular access, patients had a Silicone 12Fr (Medcomp, USA) ($n = 5$), Tesio silicone 12Fr (Medcomp, USA) ($n = 7$), Gamcath 8Fr (Gambro, Sweden) ($n = 2$), Hickman 12Fr (Bard, USA) ($n = 1$) or Ash Split type II 12Fr (Medcomp, USA) ($n = 1$) catheter, either in single ($n = 13$) or double lumen ($n = 3$) mode. A constant blood flow rate of 250 mL/min (single lumen) or 300 mL/min (double lumen) was applied using a Multimatt ($n = 3$) or Formula ($n = 13$) dialysis machine (both from Bellco, Italy).

All patients were dialysed for six consecutive sessions without using a connector on the catheter hub(s). Eleven patients were further dialyzed for one session with the Tego™ connector (ICU Medical, USA) (Figure 1A), while, afterwards, again all 16 patients were dialysed for six consecutive sessions with the BD Q-syte™ connector (Beckton-Dickinson, USA) (Figure 1B). The BD Q-syte™ connector was kept in place for an entire week. Finally, a single patient was dialyzed with a Swan Lock connector (Codan, Germany) (Figure 1C) on the catheter hub. Since it was found previously that most connector-tubing connections showed a connection play, even when the luer lock is fully tightened, significant attention was paid to ensure that the male of the tubing fully opens the split septum [7].

For each patient, blood samples were taken pre- and post-dialysis and serum lactate dehydrogenase (LDH) levels were determined with a DxC800 machine. In order to determine the degree of red blood cell fragmentation, the haemolysis index (HI) was calculated as the ratio of post-versus pre-dialysis LDH levels.

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Fig. 1. Three different closed luer lock access devices: Tego™ (panel A), BD Q-Syte™ (panel B) and Codan connector (panel C).

Table 1. Haemolysis index per patient for dialysis without a connector, with a Tego™ connector and with the BD Q-syte™ connector

Patient	Without connector	With Tego™	With BD Q-syte™
1	1.44 ± 0.61	1.06	0.96 ± 0.16
2	0.97 ± 0.09	1.01	0.96 ± 0.22
3	1.13 ± 0.07	1.27	1.02 ± 0.10
4	1.05 ± 0.21	0.94	0.98 ± 0.09
5	1.04 ± 0.11	1.45	1.15 ± 0.11
6	1.03 ± 0.11	1.04	1.04 ± 0.33
7	1.02 ± 0.24	1.11	1.06 ± 0.20
8	1.16 ± 0.16	1.31	0.97 ± 0.21
9	1.05 ± 0.07	1.00	1.02 ± 0.08
10	1.09 ± 0.08	1.21	1.12 ± 0.15
11	1.20 ± 0.16	0.87	1.13 ± 0.10
12	1.15 ± 0.22	–	1.08 ± 0.12
13	1.00 ± 0.11	–	0.95 ± 0.09
14	0.94 ± 0.24	–	1.13 ± 0.18
15	1.12 ± 0.21	–	1.10 ± 0.29
16	1.00 ± 0.17	–	1.00 ± 0.11
MEAN ± SD			
n = 11	1.11 ± 0.13	–	1.04 ± 0.07
n = 16	1.09 ± 0.12	1.12 ± 0.18	1.04 ± 0.07

Data were analysed using SigmaStat software (Jandel Scientific, San Rafael, CA, USA). Data are expressed as mean ± standard deviations. Statistical analyses were carried out using the non-parametric Wilcoxon signed rank test for paired samples and Friedman repeated measures of ANOVA on ranks. $P < 0.05$ was taken as the limit of significant difference.

Results and discussion

The BD Q-syte™ connectors were kept in place during an entire week. The Tego™ connectors, however, were all removed after a single dialysis session, since rupture of the split septum membrane was observed in few cases. The Codan connector was used only with a single patient and removed already after the first dialysis, due to leakage.

LDH is known to be increased significantly and correlate well with free haemoglobin (Hb) in blood haemolyzed by mechanical trauma especially LDH fraction 1 [8]. Furthermore, Hb levels only decrease very late in the case of haemolysis while LDH can be determined in an easy and non-expensive way and is, in contrast with Hb, not influenced by other factors like administration of erythropoietin, infection and bleeding.

The haemolysis indices, as calculated from pre- and post-dialysis LDH levels, are shown in Table 1 for the case no

connector was used, and when the Tego™ or BD Q-Syte™ connector was used. Analysis of variance (including 11 patients) unravelled no differences between the HI without a connector (1.11 ± 0.13) and with the Tego™ (1.12 ± 0.18) (although only one session) and BD Q-Syte™ connectors (1.04 ± 0.07) ($P = 0.44$). Furthermore, paired tests did not show any influence of not using any connector versus using a Tego™ connector (including 11 patients) ($P = 0.64$) or a BD Q-syte™ connector (including 16 patients) ($P = 0.21$).

In the present study, 13 out of 16 patients had a single lumen catheter and were dialyzed at a blood flow rate of 250 mL/min. The previously published *in vitro* results showed, for 250 mL/min blood flow, an additional pressure drop of 42 mmHg (BD Q-Syte™), 22 mmHg (Codan) and 10 mmHg (Tego™) for catheter inflow, while it was 26 mmHg (BD), 19 mmHg (Codan) and 13 mmHg (Tego™) for catheter outflow. Hence, from hydrodynamic point of view, the Tego™ and Codan connectors showed the most promising results. The present study, however, unravelled that we could not rely on those two types of connectors in clinical practice. Furthermore, the highest resistances, as exerted by the BD Q-Syte™ connector, did not cause any red blood cell fragmentation since all haemolysis indices were lower than 1.5 [9].

Conclusion

In order to reduce catheter-related infections with chronic haemodialysis patients, different types of closed luer lock access devices were designed to attach to the arterial and venous catheter hub, and to stay in place during the interdialytic period as well as during dialysis. Although the Tego™ connector showed promising results in the previously performed *in vitro* study [7], clinical practice revealed that, at present especially, the BD Q-Syte™ connector can be safely advised under the condition that the split septum is fully open.

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Conflict of interest statement. None declared.

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