An 18-µm microaggregate blood filter does not cause hemolysis during in vitro whole blood transfusions in sea turtles

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OBJECTIVE
Determine the hemolytic effect of an 18-µm microaggregate blood filter during in vitro sea turtle whole blood transfusions as well as describe the average diameter of leatherback (Dermochelys coriacea) and Kemp’s ridley sea turtle (Lepidochelys kempii) RBCs.

ANIMALS
5 green (Chelonia mydas), 5 loggerhead (Caretta caretta), and 5 Kemp’s ridley sea turtles (total n = 15).

METHODS
Heparinized sea turtle blood was infused at 60 mL/h through a microbore extension set without and then with a postsyringe, inline 18-µm microaggregate blood filter. Pre- and postfiltration PCV, Hct, total solids, sodium, chloride, potassium, glucose, and free plasma hemoglobin concentrations were measured. With the use of light microscopy and archived blood smears, the maximum and minimum diameter of 20 RBCs from each of the 5 leatherback and 5 Kemp’s ridley sea turtles were measured with a calibrated ocular micrometer using 400X magnification.

RESULTS
There were no significant differences between pre- and postfiltration samples for Hct, total solids, sodium, chloride, potassium, glucose, and free plasma hemoglobin concentrations; however, there was a significant median postfiltration decrease in PCV of approximately 4%, representing a 13% decrease of the total RBCs transfused. Average maximum diameters for leatherback and Kemp’s ridley sea turtle RBCs were 19.7 and 16.1 µm, respectively.

CLINICAL RELEVANCE
Although the 18-µm microaggregate blood filter does not hemolyze transfused sea turtle RBCs and is likely safe for in vivo blood transfusions, the filter’s pores may retain a small proportion of infused RBCs given their diameter.

Keywords: erythrocyte, hematology, red blood cell morphology, sea turtle rehabilitation, transfusion medicine

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short-term storage of whole blood in loggerhead sea turtles (*Caretta caretta*) given that it resulted in fewer clinicopathological changes over 24 hours when compared to sodium citrate and citrate phosphate dextrose adenine.\(^6\) Regarding pretransfusion testing, major and minor crossmatches incubated at room temperature for 30 minutes were found optimal for detecting crossmatch incompatibilities in green (*Chelonia mydas*) and loggerhead sea turtles.\(^3\) In vitro testing of allogeneic whole blood transfusions among green sea turtles found only 54% were compatible by major and minor crossmatch, whereas in vitro testing of whole blood xenotransfusions between loggerhead and green sea turtles found all were incompatible by major and minor crossmatch.\(^3\)

To the authors’ knowledge, there are no case series or prospective studies detailing in vivo blood product administration in sea turtles nor any subsequent associated transfusion reactions despite transfusions being reported anecdotally.\(^2\) Blood transfusion filters remove aggregates of cellular debris, platelets (or thrombocytes), WBCs, or fibrin that form during blood collection and storage. Consequently, the use of a blood filter during transfusion administration is considered a standard of care in human and veterinary medicine. In human medicine, commercially available standard blood filters contain pore sizes ranging from 170 to 260 µm. In domestic canine and feline patients, the Hemo-Nate blood filtration system (Utah Medical Products Inc), a disposable, stainless-steel filter with 18-µm pores designed for human neonatal blood transfusions, is frequently used as a postsyringe, inline microaggregate blood filter. The Hemo-Nate blood filtration system is advantageous in nondomestic veterinary patients, given its low priming volume (0.7 mL) and versatility to function as a postsyringe, inline filter without an extension set. Hemo-Nate blood filters do not cause significant postfiltration hemolysis in domestic chickens (*Gallus domesticus*) and American alligators (*Alligator mississippiensis*).\(^7,^8\)

## Methods

### Sea turtles and blood sampling

Five green, 5 loggerhead, and 5 Kemp’s ridley sea turtles were sourced from patients undergoing rehabilitation at the Karen Beasley Sea Turtle Rescue and Rehabilitation Center in Surf City, NC, between March and July 2023 or captured in July 2023 in actively fished pound nets in Core Sound near Cape Lookout National Seashore in conjunction with a concurrent sea turtle sex-determination study (L. Avens, PhD, Southeast Fisheries Science Center, NOAA Fisheries, unpublished data, 2023). Sea turtle age class ranged from juvenile to adult across the 3 species; median (minimum-maximum) weight for sampled green, loggerhead, and Kemp’s ridley sea turtles was 4.8 kg (3.4 to 6.8 kg), 30.0 kg (23.0 to 138.1 kg), and 3.7 kg (2.4 to 31.5 kg), respectively. All sampled sea turtles were deemed clinically healthy based on physical exam. An a priori power analysis in the statistical software R (v4.3.1)\(^9\) using the pwr package (v1.3.0)\(^10\) and its dependents determined a sample size of approximately 15 sea turtles would be sufficient to achieve a power of 80% given an alpha level of 0.05 (2-sided), mean difference of 3.2 mg/dL free plasma hemoglobin between pre- and postfiltration samples, and a SD of the differences of 4 mg/dL. The mean difference and SD of the differences were estimated using previously published data on American alligators.\(^8\)

Six milliliters of venous blood was collected aseptically from the dorsal cervical sinus of each sampled sea turtle using either 3.81-cm (1.5-inch) 18-gauge or 2.54-cm (1-inch) 21-gauge needles and a plastic syringe containing a precalculated ratio of 25 U/mL sodium heparin based upon previous research.\(^4\) All samples were gently rolled 8 to 10 times to mix the anticoagulant solution and blood following in vitro sea turtle whole blood transfusions, and 2) describe the average diameter of leatherback (*Dermochelys coriacea*) and Kemp’s ridley sea turtle (*Lepidochelys kempii*) RBCs adding to previously reported RBC morphometrics in other sea turtle species. We hypothesized there would be no significant hemolysis in postfiltration sea turtle plasma samples given Hemo-Nate blood filters do not cause significant postfiltration hemolysis in domestic chickens (*Gallus domesticus*) and American alligators (*Alligator mississippiensis*).\(^7,^8\)

### Table 1

<table>
<thead>
<tr>
<th>Sea turtle species</th>
<th>Maximum diameter (µm)</th>
<th>Minimum diameter (µm)</th>
<th>Cell area (µm²)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green (<em>Chelonia mydas</em>)</td>
<td>20</td>
<td>17</td>
<td>267</td>
<td>Work et al(^11)</td>
</tr>
<tr>
<td>Hawksbill (<em>Eretmochelys imbricata</em>)</td>
<td>20.45</td>
<td>13.74</td>
<td>221.19</td>
<td>Zhang et al(^40)</td>
</tr>
<tr>
<td>Leatherback (<em>Dermochelys coriacea</em>)</td>
<td>19.7</td>
<td>13.4</td>
<td>207</td>
<td>Present study</td>
</tr>
<tr>
<td>Loggerhead (<em>Caretta caretta</em>)</td>
<td>19.05</td>
<td>12.85</td>
<td>194.28</td>
<td>Casal and Orós(^12)</td>
</tr>
<tr>
<td>Kemp’s ridley (<em>Lepidochelys kempii</em>)</td>
<td>16.1</td>
<td>11.4</td>
<td>143.7</td>
<td>Present study</td>
</tr>
<tr>
<td>Olive ridley (<em>Lepidochelys olivacea</em>)</td>
<td>20.35</td>
<td>12.55</td>
<td>201.65</td>
<td>Zhang et al(^13)</td>
</tr>
</tbody>
</table>

Table 1—Compiled average RBC morphology for 6 of the 7 extant sea turtles from the present study and data available in prior peer-reviewed references.

To the authors’ knowledge, there are no reports of RBC morphology for flatback sea turtles (*Natator depressus*).
phlebotomy. Sea turtle blood sampling was approved by the North Carolina State University IACUC (No. 22-457). Sea turtle rehabilitation at the Karen Beasley Sea Turtle Rescue and Rehabilitation Center is performed under a permit from the North Carolina Wildlife Resources Commission (No. 23ST05). Pound netting in Core Sound was performed under a permit from the National Marine Fisheries Service (No. 21233).

**Blood filtration and data collection**

Immediately after phlebotomy, the needle was removed from the syringe containing the heparinized blood sample and replaced with a microbore T-port extension set (B. Braun) cut proximal to the male connector (T-port) at a 45° angle to its lumen to allow for nonnonturbulent blood flow. The syringe was then placed in a calibrated Triumph SP12 Syringe Pump (Triumph Medical Services) set to 60 mL/h. A standardized syringe pump infusion rate (60 mL/h) was elected to limit any confounding influence of infusion rate variability if based on patient weight. The infusion rate of 60 mL/h was chosen based on a recommended maximum transfusion rate in sea turtles of 5 mL/kg/h and a theoretical sea turtle patient weighing 12 kg. Blood was infused for 2 minutes, and a total of 2 mL was collected into a plastic microcentrifuge tube. This sample was labeled as "prefiltration" and gently agitated by hand at room temperature until processing. The microbore T-port extension set was then replaced with a Hemo-Nate blood filter, attached to a new microbore T-port extension set cut as described earlier. Blood was then infused for another 2 minutes at the same rate, and another 2 mL of blood was collected into a plastic microcentrifuge tube. This sample was labeled as "postfiltration" and gently agitated at room temperature until processing.

For both pre- and postfiltration samples, PCV and total solids (TS) were measured by micro-Hct centrifugation and a calibrated refractometer. An i-STAT CHEM8+ (Abbott Laboratories) biochemistry panel was run on the pre- and postfiltration samples within 30 minutes of infusion using an i-STAT Alinity v point-of-care analyzer (Zoetis Inc) following manufacturer instructions. The i-STAT CHEM8+ biochemistry panel measures sodium, potassium, chloride, TCO₂, anion gap, ionized calcium, glucose, BUN, creatinine, Hct, and hemoglobin. Pre- and postfiltration samples were centrifuged at 1,000 X g for 10 minutes. Free plasma hemoglobin in pre- and postfiltration samples was measured using the HemoCue Plasma/Low Hb System (HemoCue America). For centrifugation, a drop of plasma was transferred to waxed paper using a plastic disposable transfer pipette, and HemoCue Plasma/Low Hb System microcuvettes were filled and analyzed following manufacturer instructions. The HemoCue Plasma/Low Hb System is a portable photometer designed to assess human hemoglobin concentrations quickly and accurately from 0 to 3,000 mg/dL (0 to 3 g/dL) within a sample of 20 µL of plasma, serum, aqueous solutions, or blood products. Before data collection, the HemoCue Plasma/Low Hb System was calibrated following manufacturer instructions.

**RBC morphology**

Archived blood smears previously stained with a commercial Romanowsky stain variant (Hemacolor Stain Set; Sigma-Aldrich) following manufacturer’s instructions from leatherback and Kemp’s ridley sea turtles were utilized to determine average maximum and minimum diameter as well as the cell area of their RBCs. Blood smears were made using blood samples collected from free-ranging leatherback sea turtles captured during health assessments in North Carolina waters and Kemp’s ridley sea turtles who had undergone rehabilitation at the Karen Beasley Sea Turtle Rescue and Rehabilitation Center. With the use of light microscopy, blood smears from 5 individuals of both species were examined with a calibrated ocular micrometer using 400X magnification, and the maximum and minimum diameters of 20 RBCs were measured from each individual for a total of 100 RBCs per species similar to previous sea turtle hematology studies.11,12 RBC area was calculated according to the following formula as previously described as (maximum diameter × minimum diameter × π)/4.13 Historical sea turtle blood sampling of leatherback and Kemp’s ridley sea turtles was performed under appropriate North Carolina Wildlife Resources Commission (Nos. 05ST05, 07ST05, and 09ST05) and National Marine Fisheries Service (No. 21233) permits.

**Statistical analyses**

Pre- and postfiltration PCV, TS, i-STAT CHEM8+, free plasma hemoglobin, and RBC morphology results were summarized using descriptive statistics. The dependent variables PCV, TS, sodium, chloride, potassium, glucose, i-STAT Hct, and free plasma hemoglobin from pre- and postfiltration samples as well as their respective differences were assessed for normality. Given their non-Gaussian distribution, the difference in dependent variables between pre- and postfiltration samples was compared between sea turtle species included in this study using a Kruskal-Wallis test, which found no significant difference among the 3 species. Subsequently, results were aggregated regardless of species and dependent variables were analyzed by comparing paired pre- and postfiltration samples using a Wilcoxon signed-rank test. Diagnostic agreement between PCV as measured by micro-Hct centrifugation and Hct as measured by the i-STAT Alinity v point-of-care analyzer was assessed using Bland-Altman methods14 and Passing-Bablok regression.15,16 For Passing-Bablok plots and statistics, bias was calculated by subtracting the PCV result from the i-STAT Hct result. The mean bias and the limits of agreement (LOA) were then calculated; upper and lower LOA were calculated as follows:

\[ \text{LOA} = \text{Mean difference} \pm (1.96 \times \text{SD difference}) \]

Bias was considered statistically significant if the mean bias’s 95% CI did not include 0. For Passing-Bablok regression, constant bias was present if the 95% CI for the y intercept did not include 0, whereas proportional bias was present if the 95% CI for the slope did not include 1. All analyses were performed.
Table 2—Pre- and postfiltration PCV, total solids (TS), select plasma biochemical analytes, and free plasma hemoglobin (Hgb) from loggerhead (n = 5), Kemp’s ridley (5), and green sea turtles (5).

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Prefiltration</th>
<th>Postfiltration</th>
<th>Adjusted P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
<td>Minimum, maximum</td>
</tr>
<tr>
<td>PCV (%)</td>
<td>30</td>
<td>30</td>
<td>(23, 43)</td>
</tr>
<tr>
<td>iSTAT Hct (%)</td>
<td>23</td>
<td>22</td>
<td>(15, 34)</td>
</tr>
<tr>
<td>TS (g/dL)</td>
<td>5.0</td>
<td>5.0</td>
<td>(2.6, 6.8)</td>
</tr>
<tr>
<td>Sodium (mmol/L)</td>
<td>148</td>
<td>148</td>
<td>(142, 153)</td>
</tr>
<tr>
<td>Potassium (mmol/L)</td>
<td>3.5</td>
<td>3.4</td>
<td>(2.6, 4.8)</td>
</tr>
<tr>
<td>Chloride (mmol/L)</td>
<td>105</td>
<td>107</td>
<td>(89, 119)</td>
</tr>
<tr>
<td>Anion gap (mmol/L)</td>
<td>9</td>
<td>9</td>
<td>(3, 17)</td>
</tr>
<tr>
<td>Ionized calcium (mmol/L)</td>
<td>1.01</td>
<td>1.01</td>
<td>(0.82, 1.22)</td>
</tr>
<tr>
<td>Total CO₂ (mmol/L)</td>
<td>38</td>
<td>38</td>
<td>(27, 50)</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>102</td>
<td>102</td>
<td>(57, 165)</td>
</tr>
<tr>
<td>BUN (mg/dL)</td>
<td>68</td>
<td>66</td>
<td>(3, 140)</td>
</tr>
<tr>
<td>Creatinine (mg/dL)</td>
<td>0.2</td>
<td>0.2</td>
<td>(0.2, 0.6)</td>
</tr>
<tr>
<td>Hgb (g/dL)</td>
<td>7.9</td>
<td>7.7</td>
<td>(5.8, 11.6)</td>
</tr>
<tr>
<td>Plasma Hgb (mg/dL)</td>
<td>19</td>
<td>10</td>
<td>(0, 80)</td>
</tr>
</tbody>
</table>

Pre- and postfiltration samples were measured after infusing heparinized whole blood without and with a Hemo-Nate blood filter, a disposable stainless-steel filter with 18-µm pores, at 50 mL/h using a veterinary syringe pump. PCV and TS were measured by micro-Hct centrifugation and a refractometer. Plasma biochemical analytes, Hgb, and Hct were measured by an i-STAT Alinity v point-of-care analyzer. Free plasma hemoglobin was measured using the HemoCue Plasma/Low Hb System. To account for multiple comparisons, P values were adjusted using the Bonferroni correction.

N/A = Not applicable.
*Analytes that significantly differ pre- and postfiltration.

Figure 1—Bland-Altman plot of Hct measured by the i-STAT Alinity v point-of-care analyzer compared to PCV measured by micro-Hct centrifugation demonstrating a significant mean bias of −5% (95% CI, −7% to −4%). Black dots represent individual paired measurements. The mean difference (Bias, solid black line), 95% CI (red dashed lines), and the limits of agreement (black dotted-dashed lines), defined as the mean difference ± 1.96 times the SD of the differences, were calculated.
in the statistical software R (v4.3.1).9 Data organization and summary statistics were performed using the dplyr (v1.1.2)17 and psych (v2.3.6)18 packages and their dependents. Bland-Altman methods and Passing-Bablok regression were performed using the blandr (v0.5.3)19 and mcr (v1.3.2)20 packages and their dependents. To account for multiple comparisons, Wilcoxon signed-rank test P values were adjusted using the Bonferroni correction. Null hypotheses were rejected if adjusted Wilcoxon signed-rank test \( P < .05 \).

**Results**

Morphometrics of leatherback and Kemp’s ridley sea turtle RBCs are presented along with previously reported values for other sea turtle species (Table 1). Prefiltration PCV, TS, and plasma biochemistry results were within reported ranges for the 3 sea turtle species included in this study (Table 2).21 There were no significant differences between pre- and postfiltration samples for TS, sodium, chloride, potassium, glucose, i-STAT Hct, and free plasma hemoglobin; however, there was a significant difference between pre- and postfiltration samples for PCV (adjusted \( P \) value = .029). Bland-Altman methods found the i-STAT Alinity v had significant negative bias (ie, underestimates) when Hct was measured compared to PCV with a mean bias of −5% (95% CI, −7% to −4%) and lower and upper LOA of −12% (95% CI, −15% to −10%) and 2% (95% CI, −1% to 4%), respectively (Figure 1). Passing-Bablok regression analysis found an intercept of 0% (95% CI, −7.9% to 3.7%) and a slope of 1 (95% CI, 0.7% to 1.1%), indicating the i-STAT Alinity v had no significant constant or proportional bias when measuring Hct.

Figure 2—Passing-Bablok plot of Hct measured by the i-STAT Alinity v point-of-care analyzer compared to PCV measured by micro-Hct centrifugation. Passing-Bablok regression analysis found an intercept of 0% (95% CI, −7.9% to 3.7%) and a slope of 1 (95% CI, 0.7% to 1.1%) suggesting the i-STAT Alinity v had no significant constant or proportional bias when measuring Hct. Black dots represent individual paired measurements. The solid blue line and associated shading represent the estimated regression line and its 95% CI.

**Discussion**

Similar to morphology observed in other extant sea turtle species, this study found the average minimum-maximum diameter of leatherback sea turtle RBCs is 13.4 to 19.7 \( \mu \)m and the average minimum-maximum diameter of Kemp’s ridley sea turtle RBCs is 11.4 to 16.1 \( \mu \)m. Given sea turtle RBC maximum diameter may be \( \geq \) 18 \( \mu \)m, there has been historical concern that microaggregate blood filters (eg, Hemo-Nate blood filter) may cause unnecessary and potentially harmful hemolysis during the administration of whole blood or pRBCs to a sea turtle recipient. While this study found a significant median postfiltration decrease in PCV of approximately 4% (ie, from 30% to 26% or a 13% decrease in the total RBCs transfused), there was no significant postfiltration change in free plasma hemoglobin to suggest hemolysis or any of the biochemical analytes evaluated. These results suggest that although the Hemo-Nate blood filter may not hemolyze transfused sea turtle RBCs, the 18-\( \mu \)m filter’s pores likely retain a small proportion of infused RBCs given their diameter.

While permutations exist, veterinary blood transfusions are delivered via 3 general administration setups: gravity flow using a blood administration set with a built-in blood filter, peristaltic pump infusion using a blood administration set with a built-in filter, and syringe pump infusion with a post syringe, inline filter (eg, a Hemo-Nate blood filter). Due to necessary transfusion volume, gravity flow and peristaltic pump infusion are the most practical and prevalent setups in equine and large animal blood transfusions. However, blood transfusion administration setup varies in canine and feline patients due to hospital resources, standard operating procedures, as well as clinician preference. In terms of the current evidence base, one notable, in vivo experimental study22 found delivery using a syringe pump and Hemo-Nate blood filter was associated with the greatest loss of transfused RBCs after 24 hours posttransfusion, whereas subsequent in vitro canine and feline studies6,23 and 1 in vivo experimental feline study24 have found delivery using a syringe pump and Hemo-Nate blood filter have no significant impact on RBC survival posttransfusion. Although the aforementioned in vivo experimental canine study22 found delivery via gravity flow resulted in no loss of transfused RBCs after 24 hours posttransfusion, this method is potentially challenging due to its unpredictable delivery rate. Without vigilant staffing or drip infusion monitoring devices, rapid transfusion may result in transfusion-associated circulatory overload. Conversely, slow transfusion might be associated with increased blood contamination or failure to achieve the desired clinical endpoint.25 Syringe pump infusion with a Hemo-Nate blood filter provides the most customizable and accurate delivery, especially for small domestic and nondomestic veterinary patients.

It is unclear why no significant postfiltration hemolysis was observed in previous in vitro infusion studies in domestic chickens or American alligators.
larger diameter RBCs are more osmotically resistant to hemolysis than smaller diameter RBCs. Ecotothermic RBCs are more osmotically resistant to hemolysis than mammalian RBCs likely because they evolved to tolerate a wider osmotic pressure range.

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Additionally, larger diameter RBCs are more osmotically resistant to hemolysis than smaller diameter RBCs.5,26 Although RBC osmotic resistance is not equivalent to mechanical resistance, it may correlate to the decreased mechanical fragility seen in ecotothermic and larger diameter RBCs when infused through the Hemo-Nate filter. Given the apparent resistance of sea turtle RBCs to mechanical hemolysis and limited transfusion medicine research in nondenomestic veterinary patients, extrapolation of the present study's results may benefit other species, including elasmobranchs, terrestrial turtles, and lizards.27-29

The significant negative bias between PCV and Hct measured by the i-STAT Alinity v and HemoCue Plasma/Low Hb System not being validated in sea turtles and the use of a standardized syringe pump infusion rate while using the Hemo-Nate blood filter. While the i-STAT Alinity v has not been formally validated in any sea turtle species, the analyzer and its predecessor (the i-STAT 1) are widely used in sea turtle rescue, rehabilitation, and research, and plasma biochemistry results were within reported ranges for the 3 sea turtle species. Given that the HemoCue Plasma/Low Hb System quantifies free hemoglobin using a modified azide-methemoglobin reaction with absorbance measured at 2 specific wavelengths (570 and 680 nm) optimized for human hemoglobin, species-specific absorbance characteristics of oxyhemoglobin and deoxyhemoglobin in sea turtles may affect its accuracy. While the HemoCue Plasma/Low Hb System is designed for very low hemoglobin concentrations, the analyzer demonstrates nonlinearity for hemoglobin concentrations between 0 and 30 mg/dL, which may have affected the accuracy of this study's results. Given the variable weight of individual sea turtles admitted for rehabilitation depending on species and age class, a standardized syringe pump infusion rate (60 mL/h) was chosen a priori. Sea turtle whole blood transfusions are recommended to be initially delivered at a slow rate (0.25 mL/kg/h) for the first 30 minutes before increasing to 5 mL/kg/h for the remainder of the transfusion assuming no adverse transfusion reactions are observed (eg, apnea, tachypnea, arrhythmias, seizures, etc).2 Assuming a maximum transfusion rate of 5 mL/kg/h, the in vivo transfusion rates of the sea turtles sampled for this study could range from 12 to 690 mL/h (weight range, 2.4 to 138.1 kg). Based on the authors' experience, 60 mL/h would likely be too fast of a transfusion for juvenile green and Kemp's ridley sea turtles and a very slow transfusion rate for subadult to adult loggerhead sea turtles. Future investigations could explore the hemolytic effect, if any, of using the Hemo-Nate blood filter at the higher transfusion rates necessary for larger sea turtles.

Hemo-Nate blood filters are designed for small-volume transfusions; consequently, the manufacturer recommends a maximum filtration volume of 20 mL for pRBC transfusions and 50 mL for whole blood transfusions. If resistance is noted during transfusion (eg, an occlusion alarm), clinicians are advised to change the filter before continuing the transfusion. Interestingly, despite the Hemo-Nate blood filter being used most commonly (and arguably universally) postsyringe during blood transfusion administration in veterinary clinical practice and research, it is important to note this setup deviates from the recommendations provided by the manufacturer. Although the Hemo-Nate blood filter is bidirectionally supported, the manufacturer recommends the preferred approach for whole blood and pRBC transfusions is for the blood product to be aspirated through the filter (vs pushed through the filter) then transfused minus the filter postsyringe. Some have recommended prefiltersing (aspirating through the filter) whole blood and pRBC transfusions using in-line...
filters with > 170-µm pores to avoid potential stress or damage caused to the RBCs by the Hemo-Nate blood filter\(^5\); however, what effect this has on sea turtle RBCs remains unknown. The authors elected to use the Hemo-Nate blood filter postsyringe and inline in the present study to reflect likely real-world clinical use so that results could be better compared to previous blood filter research. Using a 170- to 260-µm standard blood filter or a similar albeit larger 40-µm microaggregate blood filter (eg, Haemonetics SQ40 High Flow Blood Filter) could potentially avoid the risk of hemolysis or retention of transfused RBCs altogether. Nonetheless, the authors sought to determine the hemolytic effect of Hemo-Nate blood filter given its widespread commercial availability and versatility to be used postsyringe without the need for an extension or administration set.

To synthesize the present study’s results with the current sea turtle transfusion medicine literature, sodium heparin has been recommended as the preferred anticoagulant for the collection and short-term storage of sea turtle whole blood to be used for transfusion.\(^5\) Allogenic whole blood transfusions are safer than xenotransfusions between sea turtle species; however, major and minor crossmatches incubated at room temperature for 30 minutes should be performed before every whole blood transfusion regardless of donor species.\(^3\) The frequency and occurrence of aggregates in sea turtle blood donations and the clinical consequences of transfusion to a conspecific are currently unknown, but it is likely that blood filtration is beneficial for sea turtles receiving blood transfusions and provides a standard of care similar to domestic veterinary patients. Although not evaluated in the present study, for large sea turtles undergoing rehabilitation (eg, adult green or loggerhead sea turtles), gravity flow or a peristaltic pump infusion with a blood administration set with a built-in filter is likely the most effective delivery method for whole blood transfusions. For smaller sea turtles undergoing rehabilitation (eg, Kemp’s ridley or juvenile green turtles), a syringe pump infusion with a postsyringe, inline Hemo-Nate blood filter changed every 50 mL is expected to cause no significant hemolysis based on the results of this study.

References

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