Red blood cell capacity of modern menstrual products: considerations for assessing heavy menstrual bleeding

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ABSTRACT

Background Heavy menstrual bleeding affects up to one third of menstruating individuals and has a negative impact on quality of life. The diagnosis of heavy menstrual bleeding is based primarily on history taking, which is highly dependent on traditional disposable menstrual products such as pads and tampons. Only tampons undergo industry-regulated testing for absorption capacity. As use of alternative menstrual products is increasing, there is a need to understand how the capacity of these products compare to that of standard products.

Methods A variety of commercially available menstrual products (tampons, pads, menstrual cups and discs, and period underwear) were tested in the laboratory to determine their maximal capacity to absorb or fill using expired human packed red blood cells. The volume of blood necessary for saturation or filling of the product was recorded.

Results Of the 21 individual menstrual hygiene products tested, a menstrual disc (Ziggy, Jiangsu, China) held the most blood of any product (80 mL). The perineal ice-activated cold pack and period underwear held the least (<3 mL each). Of the product categories tested, on average, menstrual discs had the greatest capacity (61 mL) and period underwear held the least (2 mL). Tampons, pads (heavy/ultra), and menstrual cups held similar amounts of blood (approximately 20–50 mL).

Conclusion This study found considerable variability in red blood cell volume capacity of menstrual products. This emphasises the importance of asking individuals about the type of menstrual products they use and how they use them. Further understanding of capacity of newer menstrual products can help clinicians better quantify menstrual blood loss, identify individuals who may benefit from additional evaluation, and monitor treatment.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Metrics for diagnosing heavy menstrual bleeding (HMB) are dependent on disposable period products (tampons and pads) and have not been modified for use with alternative products such as menstrual cups and underwear.

WHAT THIS STUDY ADDS

⇒ Menstrual cups and discs can hold ≥30 mL of blood. HMB may be underdiagnosed in users of these products. Period underwear is likely to be ineffective for those with HMB. Modern disposable period products also have a high capacity (20–50 mL) and menstrual losses are likely underestimated when using metrics developed with the use of older technology.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Clinicians can better assess menstrual blood loss in patients using their preferred menstrual product.

INTRODUCTION

Heavy menstrual bleeding (HMB) affects up to one third of menstruating individuals.[1] It is both a diagnosis unto itself and a potential indication of another underlying disorder. Clinicians routinely perform detailed menstrual histories to aid in the identification of an individual with HMB and to define the extent of the bleeding better. Patients can also self-identify as having HMB if bleeding interferes with their quality of life.[2] While a quality of life diagnosis may be all that is needed to

make a decision to treat HMB, more stringent criteria are needed to identify those with truly abnormal blood loss, potentially signifying another underlying disease (such as a bleeding disorder) or increased risk of adverse outcomes (such as iron deficiency). The ability to assess blood loss through a clinical history is critical in order to identify those in need of further medical evaluation.

This clinical evaluation has become more challenging with the availability of a wide range of alternative menstrual hygiene products. The current validated clinical tool routinely used to assess menstrual blood loss is the Pictorial Blood Loss Assessment Chart (PBAC). The PBAC is based on saturation of menstrual pads and tampons; newer menstrual hygiene products have yet to be integrated into the PBAC. To complicate matters, no industry standard exists for capacity testing of menstrual products except for tampons due to their historical link between absorbency and the risk of toxic shock syndrome.[3] Individual manufacturers may report collection capacity of their product using a liquid such as saline or water which is not equivalent to menstrual blood. Menstrual blood not only contains blood but is also composed of vaginal secretions and endometrial cells.[4] Individuals with HMB may also experience rapid blood loss (flooding) or pass clots which can further challenge the absorption of some products and lead to leaking.

Most menstruating individuals still seem to favour disposable pads and tampons, but use of alternative products is increasing. The majority of respondents to a 2022 French survey reported using disposable pads (81%) and/or tampons (45.6%); however, 15.5% used alternative products such as menstrual cups, menstrual discs, menstrual underwear or reusable pads.[5] Utilising actual menstrual blood to test the collection capacity of menstrual hygiene products would be challenging, but blood products are a closer approximation than water or saline. No study exists comparing the capacity of currently available menstrual hygiene products using blood. The objective of this study was to measure absorbency/fillable capacity of a variety of commonly used menstrual products using human blood products. These data will better allow clinicians to quantify menstrual blood loss accurately and diagnose heavy or otherwise abnormal menstrual bleeding.

MATERIALS AND METHODS

This study was approved by Oregon Health & Science University (OHSU) Institutional Review Board. Expired human packed red blood cells (RBCs) that could no longer be utilised for clinical care were obtained with permission from the OHSU pathology laboratory. The same unit of blood (O+, expired 33 days before experimentation) was used for the tampon, menstrual cup, menstrual disc, and the first trials of the pad experiments. A second unit of blood (O+, expired 58 days before experimentation) was used for the second trial of pads and the underwear experiments.

We performed all experiments utilising personal protective equipment consistent with handling human blood and disposed or cleaned all materials consistent with biohazard standard operating procedures. We obtained a variety of commercially available menstrual products (table 1).

We adapted the process for applying blood based on the type of menstrual hygiene product. For disposable pads and period underwear, RBCs were poured slowly over the central upper third of the pad/underwear until the item no longer absorbed the blood and the blood either pooled or ran off the item. For tampons, containers were each filled with 50 mL of RBCs and then each tampon was placed in its own container. Tampons remained in each container until the blood reached the wick of the tampon or 30 min elapsed, whichever occurred first. The tampons were removed from the cups and the remaining blood was measured and subtracted from 50 mL to determine total blood absorbed. For menstrual cups, each cup was held at the rim without bending and parallel to the floor. Cups were filled with RBCs, just internal to the rim without overflowing. If there was a graduated mark on the cup, this was filled and checked for accuracy. The blood was then decanted into a graduated cylinder and measured. A similar process was performed for menstrual discs.

We tested a total of 21 products with one trial each (table 2). We included two pads from one manufacturer and two pads from a second manufacturer, all with different reported absorbencies (lightdays plus/pantyliner, ultra, ultra night and heavy), one postpartum pad, and perineal cold packs (at room temperature and with ice activated). All tampons were of the same brand but different reported absorbencies (‘regular’ to ‘super plus’). The menstrual cups were the same brand with different sizes (0, 1, and 2). We used four different brands of discs, including two sizes (small and large) within the same brand. Finally, we tested three pairs of period underwear (size small, medium and large) with the same absorbency (super absorbency).

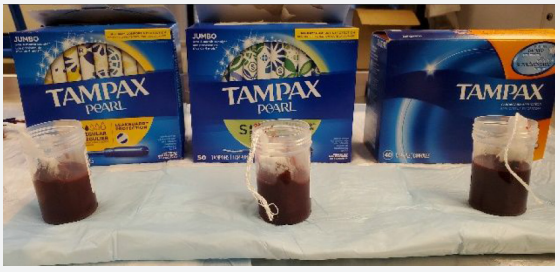
Patient and public involvement

The research question was developed based on high rates of menstrual cup use by patients seen for HMB in a combined haematology/gynaecology clinic. Lack of criteria to define ‘normal’ bleeding and/or HMB in users of cups and periods adds frustration to the patient experience as clinicians cannot provide a definitive diagnosis. Patients and/or the public were not directly involved in the design, conduct, reporting or dissemination plans of this research.

RESULTS

Of the 21 menstrual hygiene products tested, a menstrual disc (Ziggy, Jiangsu, China) held the most

Table 1 Menstrual products used

Product	Sizes	Address:	
Menstrual cups			
Diva Cup	0, 1, 2	Kitchener, Ontario, Canada	
Menstrual discs			
Intimina – Ziggy Cup	Flat fit	LELO Inc, 5799 Fontanoso Way, San Jose, CA 95138, USA	
Moonthlies menstrual disc	Small, large	PO Box 222, Spanish Fork, UT 84660, USA	
Lumma menstrual disc	Medium	999 Brickell Ave #410, Miami, FL 33131, USA	
Flex menstrual disc	n/a	318 Lincoln Blvd, Suite 200, Venice, CA 90291, USA	
Tampons			
Tampax Pearl	Regular, super, super plus	Proctor & Gamble, Auburn, ME, USA	
Pads			
U by Kotex Lightdays plus with Comfortflex design	Regular	Kimberly-Clark Corp, Dept U by KOTEX, PO Box 2020, Neenah, WI 54 957–2020, USA	
U by Kotex Security Maxi Pad	Heavy	Kimberly-Clark Corp, Dept U by KOTEX, PO Box 2020, Neenah, WI 54 957–2020, USA	
Always Ultra Long with wings	Size 2	Proctor & Gamble	
Always Ultra Night – Night with wings	Size 3	Proctor & Gamble	
Postpartum pad (Medichoice OB Peach Pad)	OB Peach Pad 7″ x 14″	Owens & Minor, 9120 Lockwood Boulevard, Mechanicsville, VA 23116, USA	
Cardinal Health Perineal Cold Pack	n/a	Cardinal Health, 7000 Cardinal Place, Dublin, OH 43017, USA	
Menstrual underwear			

Continued

Table 1 Continued

Product	Sizes	Address:	
Knix Super Absorbency	S, M, L	70 Claremont Street, Toronto, ON, Canada M6J 2M5	

n/a, not applicable/available.

of any product at 80 mL of RBCs. The perineal cold pack (room temperature and ice-activated) and one pair of period underwear held the least at 1 mL each. On average, menstrual discs held the most blood at 61 mL (SD 14 mL) and menstrual underwear held the least at 2 mL (SD 1 mL) (see table 2 and figure 1). Of note, absorbency did not vary significantly or increase with increasing size (small, medium, large) of period underwear.

DISCUSSION

We found considerable variability in the capacity of different menstrual products to collect or absorb human RBCs. Menstrual discs held the most blood in our ex vivo testing while menstrual underwear (super absorbency), regardless of size (small, medium or large) held the least. We also found that the product capacity labelling was discordant with our results—the majority of products reported that they had greater capacity than our testing found. We suspect this is due to product testing with non-blood liquids, such as water or saline.

Menstrual blood loss is typically assessed by clinicians utilising the type, number, and saturation of products per hour or day and all validated assessment tools incorporate the use of traditional menstrual pads and tampons.[6] We performed this bench-testing in order to modernise our understanding of the maximal capacity of the menstrual products that patients are increasingly using, like period underwear and menstrual cups and discs. We also wanted to test product capacity utilising a closer approximation to menstrual blood, human RBCs, rather than saline or water. Menstrual blood is likely more viscous than packed RBCs as it contains blood, tissue/cells, and other secretions. RBCs are, however, more viscous than non-blood fluids such as saline which are often used for product testing and reporting. These factors certainly have an impact on the collection capacity of menstrual products. Unfortunately, we cannot approximate the capacity of products for patients with HMB who report 'flooding' (high speed volume loss) or clotting. This type of bleeding also likely has an adverse impact on collection capacity, whereas we maximised the testing capacity of each product by slowly but consistently pouring blood or allowing the product to fully absorb (tampons). We also recognise that ex vivo testing does not necessarily represent in vivo capacity as different products bend or are compressed with wear (pads, period underwear) or vaginal use (tampons, menstrual cups and discs). Likely in vivo use lowers capacity due to changes that occur with actual use of the product.

No other published study has analysed a variety of modern menstrual products utilising RBCs. Another

Table 2 Volume of red blood cells held by each product tested

Product							
Tampons	Regular	Heavy (brand a)	Heavy (brand b)				
Volume held (mL)	20	31	34				
Pads	Light day	Heavy day (brand c)	Heavy day (brand d)	Heavy day (brand e)	Postpartum pad	Perineal cold pack with ice	Perineal cold pack without ice
Volume held (mL)	4	52	33	31	40	1	1
Discs	Brand f	Size S (brand g)	Size L (brand g)	Brand i	Brand j		
Volume held (mL)	80	40	63	59	65		
Cups	Size 0	Size 1	Size 2				
Volume held (mL)	22	25	35				
Underwear	Size small	Size medium	Size large				
Volume held (mL)	3	1	2				

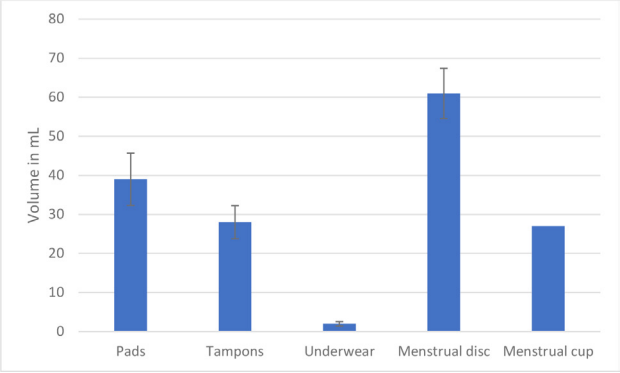


Figure 1 Average volume of red blood cells absorbed by each product category. Error bars indicate standard error. Error bars are not present for the menstrual cups as they came in discrete sizes.

ex vivo study compared volume (using water) among 14 different menstrual cups. They found considerable variation in volume between the different cups (18.88–38.14 mL).[7] We found a similar range of capacity with the menstrual cups we tested. We also demonstrated that menstrual discs have a remarkably high capacity, as advertised, up to 80 mL, which is considered to be excessive blood loss for an entire menstrual cycle.

Cups and discs held as much as—if not more than—period underwear and many disposable products. This suggests that the typical metric of soaking protection hourly as an indicator of HMB, or twice hourly as an indicator of the need for emergency treatment for acute bleeding, likely underestimates menstrual blood losses in individuals using these products. An individual must only fill a menstrual cup to the brim 3–4 times per cycle to demonstrate blood loss >80 mL, which is diagnostic of HMB. Similarly, filling two menstrual cups or one disc per hour would be the equivalent of two disposable pads per hour, or roughly 60+ mL of blood loss. Furthermore, saturation of two heavy pads (100 mL) or three heavy tampons (90 mL) represents blood loss >80 mL over the entire cycle—suggesting that the current metric of defining HMB only when a pad or tampon is saturated every 1–2 hours greatly underestimates blood loss and rates of HMB. This knowledge is critical to identify accurately when blood loss has reached a critical level with newer menstrual products, and requires the patient to seek care.

This study also demonstrated that period underwear, despite being advertised to hold many tampons worth of blood, absorbed only a very small amount of blood and quite slowly—suggesting that this is unlikely to be the menstrual product of choice for patients with 'flooding', or passage of clots, clinical features predictive of heavy bleeding. This is consistent with our clinical experience in which we find few, if any, patients with HMB utilise period underwear. Those that do, often use it as a 'backup method' under a pad or with an internal product (tampon, cup, disc), or on the lighter days when the 'flooding' episodes characteristic of HMB are less likely to occur. Similarly, we have observed a high rate of menstrual cup use in our patient population with HMB, with many cup users reporting filling a cup two or more times per day. This suggests that those with HMB may self-select for menstrual cup use and that this diagnosis may be over-represented in those who use cups. The value of this experiment is that it provides an estimate of the maximum capacity of blood contained in modern menstrual products, specifically period underwear, menstrual cups and discs. It also allows for comparison between modern products with different absorptive capacities (such as regular, ultra and overnight), something which has not been previously studied but which is an important component of the menstrual history.

Our study has a few limitations. First, period underwear may have a greater overall capacity than we found if menstrual flow is slower than that utilised in our study, although frequent reports of flooding among our patients with HMB suggests this is less likely. A second limitation is that individuals change their menstrual products not only for saturation, but also for comfort and convenience, which could result in difficulty interpreting reported use of products—that is, having to change pads five times per day might not represent five fully saturated products. When taking a menstrual history, regardless of period product type, it is important to clarify how saturated or full products are when changed. A third limitation is that, while packed RBCs are more similar to menstrual blood than saline, there are still fundamental differences which may have resulted in over- or underestimation in this study. Finally, variability in menstrual flow could result in a difference in product performance, particularly with the pads and underwear, as a significant increase in flow ('flooding') may overwhelm a product's ability to absorb, resulting in overflow or leaking and product failure. Furthermore, differences in positioning (absorbing blood from above rather than below, in the case of tampons) likely also had an impact on the results. Neither speed of flow nor differences in positioning were tested in this experiment and would be a consideration for future studies.

In summary, this study found considerable variability in RBC volume contained by menstrual products, with menstrual discs containing on average the most blood and menstrual underwear holding the least, with tampons, pads, and menstrual cups holding similar amounts. This emphasises the importance of asking individuals about the type of menstrual products they use and how they use them in order to assess menstrual blood loss better and identify those with HMB. Further understanding of capacity of newer menstrual products can help clinicians better quantify menstrual blood loss, offer diagnostic testing, and accurately treat HMB.

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