between an isolated hepatic artery and the capsular arterial plexus (4). In such cases, surgical intervention may still be necessary. The case presented here supports the practice of hepatic artery embolization for hepatic rupture in HELLP syndrome as a viable and safe treatment, and may encourage further investigation.

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Can Aprons Be Properly Evaluated for Their Protective Quality without In-House Validation?

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Editor:

Lightweight and lead-free radiation protective garments for use with fluoroscopic procedures have increased in manufacturing and clinical use owing to operator comfort. However, numerous studies have shown some garments have substantially poorer protective capacities and are not accurately represented by their labels (1,2). One study showed 30 of 41 aprons (73%) tested were outside tolerance levels (1). Another study demonstrated that scatter transmission through a lead-free garment at 60 kVp was 478% higher than through a lead garment, although still < 1% in absolute amount (3). We surveyed available manufacturer-supplied information to determine if the consumer can adequately evaluate and compare garment protection based on public information.

No universal testing standard exists for the evaluation of protective aprons. Three testing standards are optionally used by manufacturers: American Society for Testing and Materials (ASTM) F2547-06, German Institute for Standardization (DIN) 6857-1, and International Electrotechnical Commission (IEC) 61331-1:2014 and 61331-3:2014 (**Appendix A** [available online at *www.jvir.org*] [4]). ASTM does not provide for lead-equivalency values and uses narrow-beam geometry. DIN uses inverse broad-beam geometry. IEC proposes methods using narrow-beam, broad-beam, and inverse broad-beam geometries but recommends the latter 2 for garments. Broad-beam or inverse broad-beam testing setups detect fluorescence (secondary radiation emitted from apron materials, particularly low Z, when excited by the primary radiation), whereas narrow-beam geometry does this poorly because the detector is not fully exposed to these photons (**Fig a–c**), resulting in potential overestimation of protective capabilities of the material (2,3).

Attenuation varies substantially across energies secondary to photoelectric interactions, and the patterns differ for various materials (2,3,5). Therefore, a nonlead apron with lead equivalency reported at 1 or 2 beam qualities may be substantially under the labeled value at other relevant energies encountered in practice resulting in greater exposures than expected given labeled lead equivalency (1). Another problem relates to the overlap zones of some skirts and vests. Some manufacturers report lead equivalency of a single layer of the garment, whereas other manufacturers label the lead equivalency for overlapped (2) layers without disclosure, leading many operators to believe the single layer is twice its actual thickness. Unexpectedly high exposures may occur when there is a single layer anterolaterally where scatter is often projected because of operator stance.

A Google search was performed using the key words "lightweight lead aprons" in September 2015, and the first 17 manufacturer and 7 vendor websites were reviewed for available information. Lead aprons were deemed evaluable for protection if test results for at least 1 energy under any beam geometry were clearly reported, along with "clarity on overlap specifications," defined as clear information on extent of garment overlap and whether front labeled lead equivalency corresponded to a single or double (overlapped) layer. Nonlead aprons were deemed evaluable for protection if test results for ≥ 4 energies ranging from 60 to 120 kVp under broad-beam geometry were clearly reported, along with "clarity on overlap specifications." Information on material mass/area can help users compare a correlate of weight for aprons that they consider to be adequately protective. "Weight/protection" was considered evaluable if protection was evaluable and material density was disclosed.

The results are summarized in the **Table**. Websites reported when aprons were lead-free but did not always distinguish between "lead-composite" versus "lead-only." Of 24 websites, 3 listed results of multiple energies in nonlead aprons but were unclear on overlap specifications. Three websites documented broad-beam testing for nonlead products, and the remaining documented no specific testing standard or simply stated "direct beam" testing. One website provided clarity on overlap

C.R. receives personal fees from Interventco, LLC (Dallas, Texas) and has a patent for a radiation protection product. None of the other authors have identified a conflict of interest.

Appendix A is available online at *www.jvir.org*.

http://dx.doi.org/10.1016/j.jvir.2016.08.014

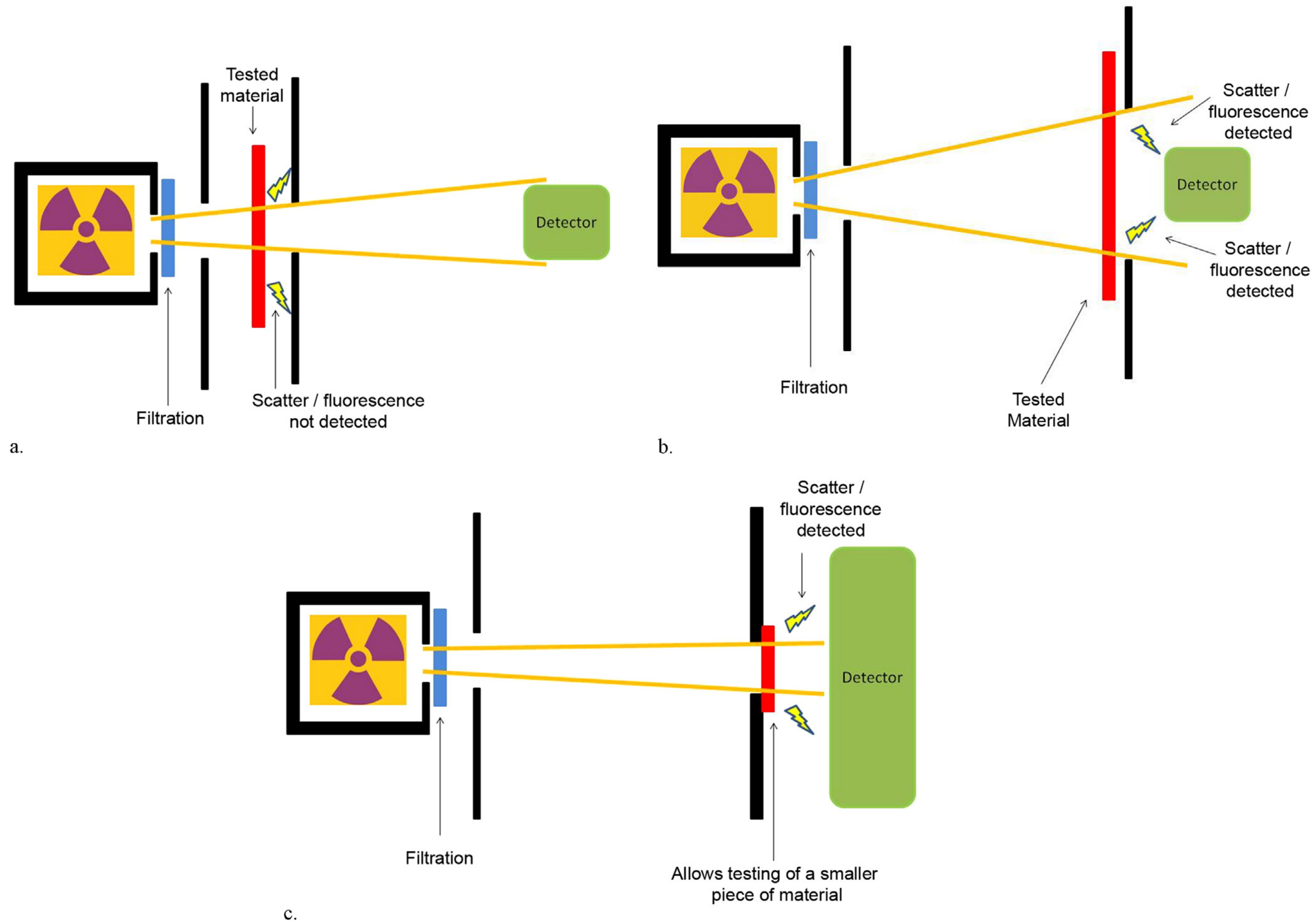

Figure. Testing geometries. Fluorescence is detected poorly by narrow-beam geometry **(a)** but is detected well by broad-beam geometry **(b)** and inverse broad-beam geometry **(c)**.

specifications but tested only a single energy for nonlead models. One manufacturer documented each metric for some, but not all, of their products, prohibiting comparison. In 1 case, the data were enough to evaluate nonoverlapping models without the ability to compare with or evaluate their overlapping models. No vendor or manufacturer provided enough information to evaluate protection for all their products by our criteria. Better clarity on overlap specifications would solve the problem for many lead-containing models, but deficiencies are more extensive for nonlead models. The authors note the search term "light-weight" could have introduced selection bias. Searches with similar terms ("lead free" and "lead composite") yielded roughly similar websites.

In conclusion, aprons are poorly evaluable using manufacturer-provided information because of the complex nature of attenuation by the materials, optional and inconsistent testing standards, and weak regulation. In-house validation of attenuation is recommended when possible, but many facilities lack the resources to perform the multienergy broad-beam testing needed for nonlead products. We believe that common, strict compliance with IEC 61331-1:2014 and IEC 61331-3:2014 would be a great step forward and would be noticed by the appearance of larger labels on garments with the extensive information described previously and in the provided appendix (**Appendix A** [available online at *www.jvir.org*]). It might take considerable time before this suggestion is widely adopted, tested, and confirmed by independent studies, which have historically been conducted by academic physicists, not by regulatory bodies. Until manufacturers provide these specifications about their products, users may benefit by requesting them from manufacturers in clearly written form, ideally permanently attached to the garment.

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