Fiona and the swallowed knit cap

Evidence assessment, fiber-specific chemistry, knitted-fabric failure modes, and time-critical clinical questions

Prepared for possible review by the Cincinnati Zoo & Botanical Garden veterinary team. Evidence cutoff: November 18, 2026, approximately 4:45 p.m. Eastern.

Scope and limitation. This is an independent desk review of publicly available information and published research, not a diagnosis or clinical treatment recommendation. No access to Fiona, the retained cap, original imaging, or veterinary records. The treating veterinarians retain all clinical authority.

Executive conclusions

- No verified public identification of the hat's fiber composition, knit construction, dimensions or remaining amount. These unknowns determine whether any biochemical hypothesis is relevant.
- Public reporting describes decreased appetite, mild dehydration, normal reported blood work, ultrasound “bunching,” and an unsuccessful 9-foot colonoscopy. The exact location of the cap and whether true obstruction or bowel plication exists remain unverified. [1–5]
- A Cincinnati Enquirer account reports that Fiona swallowed a significant part, not necessarily all, of the cap, and that some fibers have been passed. Fiber passage is not proof that the remaining material is safe or moving. [3]
- Human cellulase case reports concern plant-fiber bezoars; they do not validate dissolution of knitted cotton or other manufactured yarn in a hippo. Wool keratinase research is in vitro and often under industrial conditions. No demonstrated safe in vivo dissolution of acrylic, polyester or nylon yarn obstructions was found. [12–22]
- An intact, compressible knit might pass; selective dissolution could also release long, strong strands or expose an intact synthetic seam. The treatment target must be a safer physical configuration, not mass loss alone. [7, 8, 10, 11, 16]
- The most immediately actionable research request is access to retained fragments / excreted fibers, the original ultrasound and endoscopy details, and a clinician-led review of current obstruction risk. No experimental agent should be administered on the basis of this report.

1. Publicly established timeline and treatments

Date / status	Publicly reported facts
Nov 8, 2026	Incident date reported by Cincinnati Enquirer: a child tossed a hat that was propelled into the enclosure by a fan. Fiona swallowed a significant part of it. [3, 4]
Nov 16	Zoo publicly disclosed ingestion; round-the-clock monitoring and off-exhibit care. Michelle Curley reported a large enema, fluids and that some fibers had come out. [3]
Nov 17	Second sedation; follow-up blood work reportedly normal, mild dehydration; repeated fluid therapy, enemas, and 9-foot colonoscopy using borrowed Columbus Zoo equipment. No object reached or retrieved. Ultrasound reportedly showed some intestinal bunching. [1, 2, 4]

Date / status	Publicly reported facts
Nov 18, through review cutoff	Local and national reporting confirm reduced appetite, anti-nausea and pain medication, hydration, favorite foods, continuous monitoring, and veterinary/human expert consultations. Further procedures under consideration; no verified report of complete passage. [1, 2, 5]

Interpretation caution: “bunching” is a description, not a diagnosis of intestinal plication, ischemia, complete obstruction, or a precise segment of bowel. Public reports do not provide ultrasound images, Doppler findings, intestinal diameter, bowel motility, abdominal fluid status, fecal output trend, or a defined transition point. [1, 7, 8]

2. High-value information the treating team may already possess

Question	Why it changes the decision
What was left of the cap? Are there identifiable scraps or label photos?	Enables direct fiber identification; establishes whether it was already torn, whether seams or pom-pom remain, and whether a free yarn end exists.
What exactly passed in the feces?	A recovered fiber sample permits chemical analysis, but passed threads do not show that the main mass has cleared.
Is there a specific ultrasound transition point, plication, dilation or wall compromise?	Distinguishes a moving object, a fixed mass, linear obstruction, and nonspecific corrugation.
What did the 9-foot scope actually reach, and why was advancement stopped?	Full length, angulation, looping, inadequate preparation and safety limits imply different equipment options.
What is the current clinical trajectory?	Serial oral intake, stool output, hydration, pain, distension and imaging changes are more meaningful than hat size alone.
What exactly contraindicates surgery in Fiona?	Species-general risk versus this patient's anatomy, anesthesia tolerance and recovery logistics require different responses.

3. What hippo anatomy and ultrasound can—and cannot—tell us

Common hippos have a four-chambered stomach with extensive nonglandular fore-stomach fermentation compartments. The route, residence time and chemical environment for a treatment swallowed by mouth therefore cannot be assumed to resemble a human stomach or small intestine. [6]

In small-animal veterinary literature, a linear foreign body can become anchored proximally while the remaining strand moves distally; bowel may gather or plicate, and traction can damage or perforate intestinal tissue. That mechanism is relevant as a hypothesis for unravelled yarn, not a demonstrated diagnosis in Fiona. [7, 8]

The veterinary distinction between true plication (the entire wall and serosal contour fold) and nonspecific intestinal corrugation is consequential. Definitive diagnosis may require visualizing the

linear material in the affected lumen. Existing small-animal evidence cannot be extrapolated directly to a 2,400-lb hippopotamus. [8]

A reassuring observation would be progressive transit with stable bowel viability and clinical improvement. Worrisome observations would include persistent focal obstruction, progressive distension, compromised perfusion, free fluid, peritoneal signs or clinical deterioration. These are questions for her veterinary team, not independently confirmed findings.

4. Hat materials: a fiber-by-fiber evidence matrix

"Knit" describes the textile structure—not the chemistry. A cap may comprise several chemically different components: main yarn, elastic/ribbed band, joining seam, embroidery, a sewn-on label, tassel or pom-pom. The table gives chemical mechanisms and clinical gaps, not safe candidates for administration.

Material	Underlying chemistry	Relevant laboratory mechanism	Immediate medical assessment
Cotton / linen / hemp	Cellulose	Cellulase attacks cellulose; access depends on fiber crystallinity and yarn architecture.	Human plant-bezoar precedent only; cotton thread bezoars can obstruct. [12, 13, 17]
Rayon / viscose / lyocell / "bamboo" viscose	Regenerated cellulose	Cellulases may hydrolyze cellulose; grades differ in accessibility.	No clinical trial of knitted-fabric dissolution in bowel. [18, 21]
Wool / cashmere / alpaca / mohair	Keratin proteins	Keratinases / proteases; disulfide structure impedes breakdown.	Industrial and lab results only; concern for intestinal tissue. [18–20]
Silk	Fibroin protein	Proteases under substrate-specific conditions.	No validated intestinal yarn protocol; mucosal toxicity concern.
Polyester / recycled PET	PET ester polymer	Engineered PET hydrolases / cutinases; fiber crystallinity and process conditions inhibit rates.	No clinical dissolution of PET knit; industrial rates not transferable. [21, 22]
Acrylic / modacrylic	Polyacrylonitrile copolymer	Side-group modifications are reported; C–C backbone resists breakdown.	No credible enteral dissolution approach. [21]
Nylon / polyamide	Polyamide	Enzymatic hydrolysis literature mainly addresses oligomers/surface alteration, not rapid fabric removal.	No clinical intestinal yarn solution. [21]
Spandex / elastane, blends	Polyurethane or other elastomeric networks	Chemical treatments are highly chemistry-dependent.	Residual elastic strand may persist after another component degrades.
Polypropylene / polyethylene	Polyolefin C–C backbone	Highly resistant to digestive or ordinary textile hydrolases.	No viable bowel dissolution precedent.
Mixed fibers, seams, labels	Multiple polymers / stitching	A selective enzyme may remove one fraction, leaving a connected scaffold.	Particularly high risk of partial degradation without safe disconnection.

5. Why knitting architecture matters

In conventional weft knitting, loops of one or a small number of continuous yarns interlock. A cut or a released loop can allow a long region to ladder or unravel without destroying the underlying fiber. Knit-and-purl structure changes stretch, compressibility and how tension propagates. Machine-knit caps may include seams, overlocked edges and separately attached trims. These observations derive from textile mechanics, not an inspection of Fiona's cap. [10, 11]

Physical outcome	Potential benefit	Potential danger
Cap stays intact but compresses	Can potentially deform and transit as a soft bolus.	May compact into a plug at a narrower transition.
Cap splits into multiple short soft pieces	May reduce maximum bolus diameter.	Pieces can migrate and create multiple distal impactions.
Knit structure unravels into long continuous yarn	May reduce a compact mass.	Anchored yarn may act as a linear foreign body, leading to plication or wall injury.
Only cotton/wool part degrades	Lower total mass.	Polyester/acrylic or elastic thread may remain as a connected net or high-strength tail.
Wet textile swells, compacts or mats	Sometimes increases compliance.	May increase trapped volume, friction or fiber entanglement.
An intact seam / elastic band remains	None established.	Rigid or persistent annulus may become the obstructing residue.

Core design criterion for any hypothetical fiber modification: reduction in obstruction / traction risk without creating an anchored linear strand, large fragments, toxic products, mucosal injury, or a new obstruction farther downstream. Dry-weight loss or tensile-strength reduction alone is an insufficient endpoint.

6. Human medical precedents: what is actually proven

Study / material	Observed outcome	Transferability limitation
Carreira Delgado et al., 2014: distal ileal phytobezoar [12]	Single adult patient with complete small-bowel obstruction; cellulase and conservative management were followed by passage without surgery.	Plant matter, altered GI anatomy, medically monitored; not knitted cotton or hippo data.
Fernández Morató et al., 2009: 3 phytobezoars [13]	Three cases including one intestinal phytobezoar; cellulase used, without adverse effects reported in these cases.	Small uncontrolled series; some endoscopic treatment; cannot establish high-dose safety.
Bai et al., 2025: persimmon bezoars [14]	Two elderly patients resolved small-bowel obstruction after targeted catheter delivery of sodium bicarbonate plus decompression.	Not an enzyme, not textiles; outcomes also reflect supportive management.

Study / material	Observed outcome	Transferability limitation
Lu et al., 2022: hair + synthetic yarn [15]	Large gastric mixed hair/synthetic-yarn bezoar retrieved mechanically via endoscopy.	Not small-bowel obstruction; no chemical dissolution.
2026 trichobezoar migration case [16]	Hair fragments migrated into ileum after attempts at endoscopic fragmentation; surgery required.	Direct warning about making obstructive material more mobile.
2003 cotton thread bezoar [17]	Cotton threads accumulated in terminal ileum and required resection/anastomosis.	Demonstrates “natural” fiber does not guarantee safe passage.

Published successful case reports cannot yield a defensible percentage of passage or enzyme safety for a knitted cap. The bulk of “80–90% of foreign objects pass” statistics concerns heterogeneous objects and patients; it is not a probability estimate for a textile obstruction. [23, 30]

7. Industrial textile enzyme studies: powerful, but not clinical evidence

7.1 Wool–cotton–polyester recovery (2018)

The study “Highly Selective Enzymatic Recovery of Building Blocks from Wool-Cotton-Polyester Textile Waste Blends” used Savinase 12T protease and Cellic CTec3 cellulases on mechanically prepared material. Samples were ground to approximately 1 mm; protease treatment operated at pH 9, 50°C, with SDS and sodium bisulfite for two days, followed by cellulase treatment at pH 4.8 and 50°C for five days. The authors reported high recovery of wool amino-acid and cellulosic building blocks while polyester remained largely as a residue. These pre-processing and chemical conditions invalidate any claim that the published method is safe to give orally or rectally to Fiona. [18]

7.2 KerFJ wool degradation (2025)

A laboratory study reported purified KerFJ keratinase degraded approximately 39.7% of wool dry mass and 15.4% of human hair dry mass at 37°C over 12 hours. However, this high-concentration assay was not an animal treatment; the enzyme's optimum was pH 9.5 and 55°C, and tissue safety, oral delivery, textile architecture and relevant breakdown products were not established. It is a hypothesis-generating result only. [19]

7.3 Wool / PET / elastane recovery (2024) and synthetic barriers

Another industrial study removed wool from mixed wool/PET/elastane fabric in approximately eight hours using a novel enzyme formulation; PET was intentionally recovered intact, while elastane required a separate solvent. This exemplifies the danger of treating one material in a blend and leaving another attached. [20] Reviews emphasize high PET textile stability, polymer crystallinity, and resistance of acrylic/polyacrylonitrile carbon backbones. None supplies validated conditions suitable for a bowel lumen. [21, 22]

7.4 Safety: failure modes that matter

- Papain has documented esophageal perforation and gastric injury in human medical use; “an enzyme” does not mean gastrointestinal safety. [23]

- Industrial protease, reducing agent, surfactant, temperature and pH combinations must not be treated as clinically interchangeable with food-grade cellulases. [18, 23]
- An enzyme safe for food processing or oral ingestion may still be harmful in high local concentration against compromised intestinal mucosa, or ineffective by the time it reaches the target.
- Breakdown products, dissolved dyes, finishes, fragments, remaining synthetic components and microbiome effects must all be evaluated; these were not established for Fiona.

8. Device, surgical and imaging options: bounded feasibility review

Pathway	What evidence establishes	What it does NOT establish
Serial ultrasound / targeted imaging	Already used in Fiona; veterinary linear-foreign-body literature shows plication and mural signs can sometimes be identified. [1, 8]	An image has not publicly localized her cap or proven complete obstruction.
Retrograde colonoscopy	Zoo attempted a borrowed ~9-ft instrument and could not reach the object. [1, 4]	Does not tell us if travel was limited by physical length, looping, anatomy or safety.
Balloon-assisted enteroscopy	Fujifilm EN-840T: 2,000-mm working length, 3.2-mm therapeutic channel; a human distal-ileal foreign body was retrieved in 2026 using double-balloon technique. [24, 25]	Human enteric anatomy, anesthesia and traction risks do not demonstrate feasibility in Fiona.
Abdominal surgery / laparoscopy	Successful common-hippo open ovariectomy; successful pygmy-hippo ileal resection and reconnection. [26, 27]	Not equivalent to safe surgery on Fiona; large-hippo anesthesia and wound risks are serious. [28]
Capsule / untethered robot	Clinical capsule imaging exists.	Suspected obstruction makes retention a serious hazard; not an appropriate experimental scout without veterinary justification. [29]

Published hippo operations do not override Dr. Wenninger's patient-specific clinical conclusion that surgery is not an option. The appropriate question is what operative, anesthetic or postoperative factor makes it unacceptable *for Fiona*. Likewise, a balloon endoscope is not automatically the answer to a failed conventional colonoscopy.

9. Priority-ordered research and consultation plan

These activities are proposed for the zoo's approval and oversight; they are not requests to change treatment before the clinical team assesses risk.

1. Clinical evidence consolidation: review the complete ultrasound cine loops, Doppler and serial bowel measurements, oral/fecal intake-output history, examination records, and the exact colonoscopy endpoint. Resolve whether material is progressing, plicated, impacted or unlocalized.

2. Material evidence acquisition: collect any retained cap fragment, exact-product label/photo (if voluntarily provided), fibers already passed in stool, and all attached trims/seams. Record sample provenance and whether multiple yarn types are present.
3. Rapid non-destructive fiber identification: use microscopy plus FTIR/Raman as appropriate; analyze mixture proportions with validated textile methods such as AATCC TM20/TM20A. Avoid assuming “knit cap” implies wool. [9]
4. Knit-failure characterization: image the loop pattern and terminal ends; quantify unravelling mode, cut/seam placement, number of independent yarns, and residual elastic / synthetic components. A textile engineer should assess wet-state tensile behavior and safe fragment morphology. [10, 11]
5. Only then, low-risk benchtop comparison: in physiologically appropriate simulated fluids, measure intact-cap compressibility and transit-relevant geometry before/after candidate enzyme exposure, with no animal administration. Assess strand-length distribution, remaining seams and byproducts; stop candidates that form long linear residue.
6. Independent time-limited expert review: zoo clinicians should decide whether advanced imaging, modified endoscopic access or another established procedure has a better risk profile than continued supportive care; researchers can supply literature and device facts, not overrule bedside judgment.

10. Twelve questions for Cincinnati Zoo veterinary leadership

1. Is any piece of the actual hat available, and can a few milligrams of passed fibers be supplied for independent textile identification?
2. Was the swallowed object the whole cap, a substantial fragment, or multiple fragments? Does the retained piece include the seam, ribbing, pom-pom or elastic?
3. Have passed fibers been retained, photographed and compared with the cap?
4. Has ultrasound identified true small-bowel plication or only nonspecific bunching/corrugation? Were Doppler perfusion, bowel wall thickness and free fluid assessed?
5. Has a fixed transition point or evidence of a complete rather than partial obstruction been demonstrated?
6. Is the object definitely in the small intestine, or is that currently a working hypothesis?
7. Are current eating, fecal output and clinical signs improving, stable or worsening?
8. What exact anatomical landmark did the nine-foot colonoscope reach, and why could it advance no farther?
9. Would existing balloon-assisted enteroscopy or a different imaging route be technically assessable, or has it already been excluded for a documented reason?
10. What specifically makes abdominal surgery unacceptable for Fiona: access, anesthesia, bowel repair, wound closure, or recovery?
11. Would a short independent textile and GI-device feasibility consultation provide useful information without delaying treatment?
12. What is the safest channel through which to deliver a concise sourced technical review to the team without distracting clinicians?

11. Interpretation and decision boundaries

Most credible near-term value: accurate diagnosis, fiber identification, characterization of the remaining knit, and expert clarification of accessible versus inaccessible treatment options. A monitored supportive-care pathway may remain the safest option, particularly if transit is occurring and bowel integrity is preserved.

Highest-risk leap: assuming that a positive laboratory degradation assay implies safe intraintestinal application. In the absence of material identification, clinical localization, stability evidence and validated safety, novel enzymes, caustic agents, hot solutions, solvents, forced fragmentation and unsupervised retrieval are not justified by the studies reviewed here.

This is an evidence map, not a replacement for Fiona's treating clinicians or a guarantee that an overlooked intervention exists.

References and source links

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