Access this article online
Quick Response Code:

Website:
www.herniasurgeryjournal.org
DOI:
10.4103/ijawhs.ijawhs_47_24

Submitted: 30-Jul-2024
Accepted: 05-Aug-2024
Published: 08-Oct-2024

Comment to "Per- and poly-fluoroalkyl substances (PFAS) in hernia meshes: Weighing the evidence and implications of upcoming EU legislation"

Dear Sir/Madam,

We would like to thank the authors for bringing up for discussion the important topic of poly-fluoroalkyl substances (PFAS) in hernia surgery with their letter to the editor. The topic is highly complex and controversial in many aspects. With this response, we would like to add additional important information that is, urgently needed for a better understanding of the topic.

"The Many Types of" PFAS—Background Information

PFAS are used in thousands of applications—the vast majority and most relevant in terms of quantity in nonmedical applications are: electronics and chip manufacturing, energy, technical gases, construction, textiles, and carpets.

PFASs are a group of more than 10,000 substances with diverse molecular structures and physical, chemical, and biological properties. This diversity must be properly recognized and communicated in a clear, specific, and descriptive manner as stated in a recent Organization for Economic Co-operation and Development (OECD) report dealing with the terminology of PFAS.[1] The aforementioned OECD report further states: "'PFASs' is a broad, general, nonspecific term, which does not inform whether a substance is harmful or not."[1]

According to the definition in the restriction proposal, PFAS are all compounds that have at least one fully fluorinated aliphatic carbon atom. These fluorine-carbon bonds are extremely stable, and PFASs owe their moniker of "forever chemicals" to this very stability. If these substances are released into the environment, there are no natural processes that can break down these extremely strong bonds. This property is the actual trigger for the restriction proposal: Once in the environment, PFAS are extremely persistent. The legitimate concern is that PFAS substances bioaccumulate over time and may have other consequences that are not foreseeable today.

ECHA Restriction Proposal and the Proceeding

The restriction proposal is structured according to application sectors and applications and comprises more than 1,800 pages. Depending on the type of application, the proposal includes time-limited derogations (18 months transition period, 6.5 years or 13.5 years) as well as time-unlimited derogations for the continued use of PFAS. The European Chemicals Agency (ECHA) was commissioned to evaluate the restriction proposal. As one step of this evaluation, stakeholders submitted detailed information for each application to the ECHA as part of a consultation procedure until September 2023: More than 4,400 organizations, companies, and individuals submitted more than 5,600 comments filling over 100,000 pages—a record. The information is currently being reviewed by ECHA's scientific committees for Risk Assessment and Socio-Economic Analysis. ECHA will forward the final opinions to the European Commission, which will then decide on the possible restriction.

OECD "Polymer of Low Concern" Criteria

Polymers of low concern are those deemed to have insignificant environmental and human health impacts, according to the OECD.[2]

"Polymer of low concern" (PLC) criteria were developed within regulatory frameworks around the world over time to report a polymer's potential hazard. The criteria are determined by chemical hazard assessment processes, which identify physical-chemical properties of polymers. Fluoropolymers, including polytetrafluoroethylene (PTFE) and polyvinylidene difluoride (PVDF), fulfill the strict OECD PLC criteria.[3,4] Fluoropolymers are neither bioavailable nor bioaccumulative. These solid polymers cannot be absorbed through a cell membrane via passive or active transport and do not bind or interact with the cell surface.[4]

Hernia Meshes—Health Impact

From the group of more than 10,000 PFAS, only a few selected PFAS are used in medical devices. In each case, these must meet the strict approval requirements that are standard in medical technology. The detailed assessment of possible health risks posed by the materials used is an integral part of this strict approval process. This aspect is a decisive difference between PFAS used in medical devices and the vast majority of all other PFAS used in non-medical applications. Despite the approval process, medical devices made of PFAS have not received a time-unlimited derogation in the proposal. In contrast, PFAS used for pharmaceuticals have received a time-unlimited derogation precisely because of the presence of a separate approval process. Numerous major medical societies have addressed the issue as part of the consultation procedure and are publicly calling for PFAS used in medical devices not to be restricted—with the explicit aim of ensuring patient safety in the long term.[5] In most cases, these PFAS are stable fluoropolymers such as PTFE or PVDF that have already been used for decades with great success in many different medical applications, without any indication of possible negative health effects.

Among the medical societies mentioned are:

- European Society for Vascular Surgery
- International Society for Gynecologic Endoscopy
- EURETINA—European Society of Retina Specialists
- European Respiratory Society
- European Society of Anesthesiology and Intensive Care
- American Thoracic Society
- European Society for Medical Oncology

Hernia Meshes—Degradation and Long-Term Stability

Contrary to the authors' claims, there are a large number of reliable studies that clearly show that fluoropolymers are superior to alternative polymers, in particular polypropylene (PP), in terms of degradation and long-term stability.[6-16] Even in the 2018 version of the "International guidelines for groin hernia management," a group of experts has addressed the issue of mesh degradation in great depth and concluded based on the evidence in literature: "PVDF has the highest resistance to degradation."[17] The restriction proposal itself is the latest weighty proof of the long-term stability of fluoropolymers: They are so stable that they face the accusation of unlimited long-term stability. For use in long-term implants, which in some cases remain in the body for 50, 60, or more years, unlimited long-term stability is exactly what patients and users want. Only fluoropolymers, such as PTFE and PVDF, currently fulfill these requirements. The authors of the Letter to the Editors themselves published an analysis from the Danish Hernia Database with a 10-year follow-up on eight different mesh implants. In this study, PVDF mesh implants had the lowest reoperation rates due to recurrence.[18] These data are consistent with all existing findings on the superior long-term stability of PVDF compared with alternative polymers, such as PP and polyethylene terephthalate (PET).

I would like to take this opportunity to present my personal (Prof. B. Klosterhalfen) assessment of degradation and long-term stability, which is based on my expertise from more than 30 years as a clinical pathologist. During this time, I have analyzed thousands of mesh explants (hernia and urology/gynecology) that now constitute the world's largest database of explanted mesh implants. For the last 15 years, I have been an expert witness in mass litigations in the United States of America and Australia with more than 200,000 claims for damages following the use of hernia and pelvic floor meshes made of PP and PET.[19,20]

The results of my research prove higher complication rates in the long term with mesh implants made from PP and PET. Both of these polymers exhibit a significant degree of degradation over time in the patient.[6-15,21-25] PVDF, however, remains stable for decades without signs of degradation or loss of function in the patient's body after long-term implantation.

Environmental Impact

To assess the environmental impact, it is important to make a distinction between volatile and non-volatile PFAS. About twice as much volatile PFAS are used annually as PFAS in the form of solids/fluoropolymers.[26] The difference in volatility is crucial: volatile PFAS are much more mobile than polymers and can therefore spread in the environment much more easily. In contrast, main-chain fluoropolymers such as PVDF and PTFE used in medical technology, including hernia surgery, can be handled in a controlled manner throughout their whole life cycle. There are technologies available that allow for PFAS-free synthesis of main-chain fluoropolymers. At the

end of the life cycle, when disposed of appropriately, the polymers can be thermally decomposed into non-PFAS constituents.

Conclusions

There are essential applications that do not work without PFAS. Medical care as we know it today is inconceivable without PFAS, neither in the field of pharmaceuticals nor in the field of medical technology. In addition to implants, such as hernia meshes, many other medical devices contain PFAS: vascular prostheses, pacemakers or stents, catheters (especially those with lubricious coatings) all types of energy-conducting minimally invasive instruments, programmable electrical medical devices, such as incubators, computed tomography, magnetic resonance imaging, dialysis machines, heart-lung machines, ventilators, syringe pumps, and many thousands of other essential products are affected.[27] In Germany alone, there are over 150,000 different medical devices without which around 30 million hospital treatments per year would no longer be possible. The medical societies have understood this and have made their position clear. Users and patients should also be aware of this.

Ethical policy and institutional review board statement

Not applicable.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Acknowledgement

Not applicable.

Bernd Klosterhalfen[1], Konstantinos Zarras[2]

[1]Institute for Pathology, Düren Hospital, Düren, [2]Clinic for Visceral, Minimally Invasive and Oncological Surgery, Marien Hospital Duesseldorf, Duesseldorf, Germany

Address for correspondence: Prof. Bernd Klosterhalfen, Institute for Pathology, Düren Hospital, Merzenicher Straße 37, Düren D-52351, Germany. E-mail: bernd.klosterhalfen@web.de

References

1. Organization for Economic Co-operation and Development (OECD). Reconciling Terminology of the Universe of Per- and Polyfluoroalkyl Substances: Recommendations and Practical Guidance. Paris: OECD; 2021.
2. Organization for Economic Co-operation and Development (OECD). Data Analysis of the Identification of Correlations between Polymer Characteristics and Potential for Health or Ecotoxicological Concern. OECD Task Force on New Chemicals Notification and Assessment, Expert Group Meeting on Polymers; 2007 March; Tokyo, Japan. Paris: OECD; 2009.
3. BIO by Deloitte. Technical Assistance Related to the Review of REACH with Regard to the Registration Requirements on Polymers Final Report Prepared for the European Commission (DG ENV), in Collaboration with PIEP. 2015.
4. Korzeniowski SH, Buck RC, Newkold RM, Kassmi AE, Laganis E, Matsuoka Y, *et al*. A critical review of the application of polymer of low concern regulatory criteria to fluoropolymers II: Fluoroplastics and fluoroelastomers. Integr Environ Assess Manag 2023;19:326-54.
5. Comments submitted to date on restriction report on PFAS: ECHA. Available at the website of ECHA.
6. Iakovlev VV, Guelcher SA, Bendavid R. Degradation of polypropylene in vivo: A microscopic analysis of meshes explanted from patients. J Biomed Mater Res B Appl Biomater 2015;105:237-48.
7. Mary C, Marois Y, King MW, Laroche G, Douville Y, Martin L, *et al*. Comparison of the in vivo behavior of polyvinylidene fluoride and polypropylene sutures used in vascular surgery. ASAIO J 1998;44:199-206.
8. Silva RA, Silva PA, Carvalho ME. Degradation studies of some polymeric biomaterials: Polypropylene (PP) and polyvinylidene difluoride (PVDF). Mater Sci Forum 2007;539-543:573-6.
9. Cozad MJ, Grant DA, Bachman SL, Grant DN, Ramshaw BJ, Grant SA. Materials characterization of explanted polypropylene, polyethylene terephthalate, and expanded polytetrafluoroethylene composites: Spectral and thermal analysis. J Biomed Mater Res B Appl Biomater 2010;94B:455-62.
10. Klink CD, Junge K, Binnebösel M, Alizai HP, Otto J, Neumann UP, *et al*. Comparison of long-term biocompability of PVDF and PP meshes. J Invest Surg 2011;24:292-9.
11. Wang H, Klosterhalfen B, Müllen A, Otto T, Dievernich A, Jockenhövel S. Degradation resistance of PVDF mesh in vivo in comparison to PP mesh. J Mech Behav Biomed Mater 2021;119:104490.
12. Wang H, Klosterhalfen B, Klinge U, Müllen A, Jockenhoevel S. Influence of polypropylene mesh degradation on tissue inflammatory reaction. J Biomed Mater Res A 2023;111:1110-9.
13. Costello CR, Bachman SL, Ramshaw BJ, Grant SA. Materials characterization of explanted polypropylene hernia meshes. J Biomed Mater Res B Appl Biomater 2007;83:44-9.
14. Clavé A, Yahi H, Hammou J-C, Montanari S, Gounon P, Clavé H. Polypropylene as a reinforcement in pelvic surgery is not inert: Comparative analysis of 100 explants. Int Urogynecol J 2010;21:261-70.
15. Smith SE, Cozad MJ, Grant DA, Ramshaw BJ, Grant SA. Materials characterization of explanted polypropylene hernia mesh: Patient factor correlation. J Biomater Appl 2016;30:1026-35.
16. Laroche G, Marois Y, Schwarz E, Guidoin R, King MW, Pâris E, *et al*. Polyvinylidene fluoride monofilament sutures: Can they be used safely for long-term anastomoses in the thoracic aorta? Artif Organs 1995;19:1190-9.
17. The HerniaSurge Group. International guidelines for groin hernia management. Hernia 2018;22:1-165.
18. Baker JJ, Öberg S, Rosenberg J. Reoperation for recurrence is affected by type of mesh in laparoscopic ventral hernia repair: A nationwide cohort study. Ann Surg 2023;277:335-42.
19. Dyer O. Johnson and Johnson faces lawsuit over vaginal mesh devices. BMJ 2016;353:i3045.
20. Legal news: Mesh medical device news desk. Available at the website of MESHNEWSDESK.
21. Jain T, Tantisuwanno C, Paul A, Takmakov P, Joy A, Isayeva I, *et al*. Accelerated in vitro oxidative degradation testing of polypropylene surgical mesh. J Biomed Mater Res B Appl Biomater 2023;111:2064-76.

22. Taylor D. The failure of polypropylene surgical mesh in vivo. J Mech Behav Biomed Mater 2018;88:370-6.
23. Imel A, Malmgren T, Dadmun M, Gido S, Mays J. In vivo oxidative degradation of polypropylene pelvic mesh. Biomaterials 2015;73:131-41.
24. Farr NTH, Roman S, Schäfer J, Quade A, Lester D, Hearnden V, *et al*. A novel characterisation approach to reveal the mechano-chemical effects of oxidation and dynamic distension on polypropylene surgical mesh. RSC Adv 2021;11:34710-23.
25. Sternschuss G, Ostergard DR, Patel H. Post-implantation alterations of polypropylene in the human. J Urol 2012;188: 27-32.
26. ECHA restriction proposal: Annex XV report. Available at the website of ECHA.
27. PFAS-Verbot: Sie müssen sofort handeln. Available at the website of Johner Institut.

How to cite this article: Klosterhalfen B, Zarras K. Comment to "Per- and poly-fluoroalkyl substances (PFAS) in hernia meshes: Weighing the evidence and implications of upcoming EU legislation" Int J Abdom Wall Hernia Surg 2024;7:150-3.