



Descending aorta subject-specific one-dimensional model validated against *in vivo* data



E. Bollache^{a,b}, N. Kachenoura^b, A. Redheuil^{b,c}, F. Frouin^b, E. Mousseaux^{b,c}, P. Recho^d,
D. Lucor^{a,*}

^a UPMC Univ Paris 06, CNRS UMR 7190, Institut Jean Le Rond d'Alembert, F-75005 Paris, France

^b UPMC Univ Paris 06, Sorbonne UMR_S 676, Laboratoire d'Imagerie Fonctionnelle, F-75003 Paris, France

^c European Hospital Georges Pompidou, Unité Paris Descartes and Assistance Publique Hôpitaux de Paris, Cardiovascular Imaging Department, Paris, France

^d Laboratoire PHARM, ESPCI/CNRS-UMR 7626/Paris, Paris 6 UPMC/Univ Paris 7 Diderot, 10 rue Vauquelin, 75231 Paris cedex 05, France

ARTICLE INFO

Article history:

Accepted 6 November 2013

Keywords:

Reduced model

Arterial pulse wave propagation

Magnetic resonance imaging

ABSTRACT

The aorta plays a major role in the cardiovascular system and its function and structure are primarily affected by aging, eating habits, life style and other cardiovascular risk factors, inducing increased stiffness which is associated with cardiovascular and cerebral morbi-mortality. Our objective was to develop and validate a robust subject-specific one-dimensional wave propagation numerical model of the descending aorta. This model with a cross-sectional area, velocity and pressure formulation is built using geometric and hemodynamic data measured on a specific person and is validated against *in vivo* data acquired on the same subject at three distinct anatomical locations along the thoracic aorta. We studied seven healthy volunteers, who underwent carotid applanation tonometry and aortic cardiovascular magnetic resonance (CMR). Responses of our model in terms of changes in central pressure waveform with arterial alterations were consistent with previously described physiological knowledge. Quantitative validation averaged over the three descending aortic locations and the seven subjects provided low rms errors (given in percentage of the maximal clinical value) between simulated and CMR data, i.e. area: $10 \pm 6\%$, velocity: $11 \pm 3\%$, flow rate: $9 \pm 3\%$. Finally, we also found low rms ($5 \pm 2\%$) when comparing simulated pressure in the proximal aortic location against tonometric carotid pressure curves. In conclusion, this simple model performs similar to more complex models of the entire systemic arterial tree at a fraction of the cost, and could be of major usefulness in the non-invasive and local estimation of proximal biomechanical and hemodynamic indices.

© 2013 Elsevier Ltd. All rights reserved.

1. Introduction

Both structural and functional alterations of large arteries, especially the aorta, occur with aging as well as with aggravating pathologic, genetic and environmental factors (Lakatta and Levy, 2003), resulting in arterial stiffening which has been associated with cardiovascular and cerebral morbi-mortality (Mitchell et al., 2010). One-dimensional (1D) computational fluid dynamics models, simulating parts or the entire systemic circulation, are widely used for studying arterial pressure and flow waves (Stergiopoulos

et al., 1992; Olufsen et al., 2000; Segers and Verdonck, 2000; Sherwin et al., 2003; Steele et al., 2003; Wang and Parker, 2004; Bessens et al., 2007; Matthys et al., 2007; Alastruey et al., 2008; Bessens et al., 2008; Raymond et al., 2009, 2011, 2012). Indeed, they can provide insights into wave propagation and reflection, allowing for a better characterization of the arterial system and its interactions with target organs. Despite their approximations and sensitivity to changes in arterial caliber and distensibility, as well as to peripheral wave reflections, 1D models are computationally attractive, compared to the more accurate three-dimensional models. Valid questions are whether 1D models may be easily adapted to a specific subject, i.e. which features and parameters must be precisely tuned? and how to quantitatively validate model predictions? To date, when available, validations of 1D models including the aorta were performed against either *in vitro* (Segers and Verdonck, 2000; Matthys et al., 2007; Huberts et al., 2012) or *in vivo* (Stergiopoulos et al., 1992; Olufsen et al., 2000; Steele et al., 2003; Raymond et al., 2009, 2011) data. Among these studies,

* Corresponding author at: CNRS UMR 7190, Institut Jean Le Rond d'Alembert, F-75005 Paris, France. Tel.: +33 1 44 27 54 72.

E-mail addresses: emmanuel.bollache@imed.jussieu.fr (E. Bollache),

nadja.kachenoura@inserm.fr (N. Kachenoura),

alban.redheuil@gmail.com (A. Redheuil),

federique.frouin@imed.jussieu.fr (F. Frouin),

eric.mousseaux@gmail.com (E. Mousseaux),

pierre.recho@univ-paris.fr (P. Recho), daniel.lucor@aphp.fr (D. Lucor).

Journal Of Biomechanics

Rosina Ehmann



Journal Of Biomechanics:

Eventually, you will totally discover a new experience and completion by spending more cash. yet when? accomplish you say yes that you require to acquire those every needs later than having significantly cash? Why dont you try to acquire something basic in the beginning? Thats something that will lead you to understand even more something like the globe, experience, some places, past history, amusement, and a lot more?

It is your unquestionably own grow old to perform reviewing habit. in the middle of guides you could enjoy now is **Journal Of Biomechanics** below.

<https://staging.conocer.cide.edu/About/detail/fetch.php/fort%20worth%20isd%20alg%201%20eoc%20assessment.pdf>

Table of Contents Journal Of Biomechanics

1. Understanding the eBook Journal Of Biomechanics
 - The Rise of Digital Reading Journal Of Biomechanics
 - Advantages of eBooks Over Traditional Books
2. Identifying Journal Of Biomechanics
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Journal Of Biomechanics
 - User-Friendly Interface
4. Exploring eBook Recommendations from Journal Of Biomechanics
 - Personalized Recommendations
 - Journal Of Biomechanics User Reviews and Ratings
 - Journal Of Biomechanics and Bestseller Lists
5. Accessing Journal Of Biomechanics Free and Paid eBooks

- Journal Of Biomechanics Public Domain eBooks
- Journal Of Biomechanics eBook Subscription Services
- Journal Of Biomechanics Budget-Friendly Options
- 6. Navigating Journal Of Biomechanics eBook Formats
 - ePub, PDF, MOBI, and More
 - Journal Of Biomechanics Compatibility with Devices
 - Journal Of Biomechanics Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Journal Of Biomechanics
 - Highlighting and Note-Taking Journal Of Biomechanics
 - Interactive Elements Journal Of Biomechanics
- 8. Staying Engaged with Journal Of Biomechanics
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Journal Of Biomechanics
- 9. Balancing eBooks and Physical Books Journal Of Biomechanics
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Journal Of Biomechanics
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Journal Of Biomechanics
 - Setting Reading Goals Journal Of Biomechanics
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Journal Of Biomechanics
 - Fact-Checking eBook Content of Journal Of Biomechanics
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development

- Exploring Educational eBooks

14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

Journal Of Biomechanics Introduction

Journal Of Biomechanics Offers over 60,000 free eBooks, including many classics that are in the public domain. Open Library: Provides access to over 1 million free eBooks, including classic literature and contemporary works. Journal Of Biomechanics Offers a vast collection of books, some of which are available for free as PDF downloads, particularly older books in the public domain. Journal Of Biomechanics : This website hosts a vast collection of scientific articles, books, and textbooks. While it operates in a legal gray area due to copyright issues, its a popular resource for finding various publications. Internet Archive for Journal Of Biomechanics : Has an extensive collection of digital content, including books, articles, videos, and more. It has a massive library of free downloadable books. Free-eBooks Journal Of Biomechanics Offers a diverse range of free eBooks across various genres. Journal Of Biomechanics Focuses mainly on educational books, textbooks, and business books. It offers free PDF downloads for educational purposes. Journal Of Biomechanics Provides a large selection of free eBooks in different genres, which are available for download in various formats, including PDF. Finding specific Journal Of Biomechanics, especially related to Journal Of Biomechanics, might be challenging as theyre often artistic creations rather than practical blueprints. However, you can explore the following steps to search for or create your own Online Searches: Look for websites, forums, or blogs dedicated to Journal Of Biomechanics, Sometimes enthusiasts share their designs or concepts in PDF format. Books and Magazines Some Journal Of Biomechanics books or magazines might include. Look for these in online stores or libraries. Remember that while Journal Of Biomechanics, sharing copyrighted material without permission is not legal. Always ensure youre either creating your own or obtaining them from legitimate sources that allow sharing and downloading. Library Check if your local library offers eBook lending services. Many libraries have digital catalogs where you can borrow Journal Of Biomechanics eBooks for free, including popular titles. Online Retailers: Websites like Amazon, Google Books, or Apple Books often sell eBooks. Sometimes, authors or publishers offer promotions or free periods for certain books. Authors Website Occasionally, authors provide excerpts or short stories for free on their websites. While this might not be the Journal Of Biomechanics full book , it can give you a taste of the authors writing style. Subscription Services Platforms like Kindle Unlimited or Scribd offer subscription-based access to a wide range of Journal Of Biomechanics eBooks, including some popular titles.

FAQs About Journal Of Biomechanics Books

How do I know which eBook platform is the best for me? Finding the best eBook platform depends on your reading preferences and device compatibility. Research different platforms, read user reviews, and explore their features before making a choice. Are free eBooks of good quality? Yes, many reputable platforms offer high-quality free eBooks, including classics and public domain works. However, make sure to verify the source to ensure the eBook credibility. Can I read eBooks without an eReader? Absolutely! Most eBook platforms offer webbased readers or mobile apps that allow you to read eBooks on your computer, tablet, or smartphone. How do I avoid digital eye strain while reading eBooks? To prevent digital eye strain, take regular breaks, adjust the font size and background color, and ensure proper lighting while reading eBooks. What the advantage of interactive eBooks? Interactive eBooks incorporate multimedia elements, quizzes, and activities, enhancing the reader engagement and providing a more immersive learning experience. Journal Of Biomechanics is one of the best book in our library for free trial. We provide copy of Journal Of Biomechanics in digital format, so the resources that you find are reliable. There are also many Ebooks of related with Journal Of Biomechanics. Where to download Journal Of Biomechanics online for free? Are you looking for Journal Of Biomechanics PDF? This is definitely going to save you time and cash in something you should think about. If you trying to find then search around for online. Without a doubt there are numerous these available and many of them have the freedom. However without doubt you receive whatever you purchase. An alternate way to get ideas is always to check another Journal Of Biomechanics. This method for see exactly what may be included and adopt these ideas to your book. This site will almost certainly help you save time and effort, money and stress. If you are looking for free books then you really should consider finding to assist you try this. Several of Journal Of Biomechanics are for sale to free while some are payable. If you arent sure if the books you would like to download works with for usage along with your computer, it is possible to download free trials. The free guides make it easy for someone to free access online library for download books to your device. You can get free download on free trial for lots of books categories. Our library is the biggest of these that have literally hundreds of thousands of different products categories represented. You will also see that there are specific sites catered to different product types or categories, brands or niches related with Journal Of Biomechanics. So depending on what exactly you are searching, you will be able to choose e books to suit your own need. Need to access completely for Campbell Biology Seventh Edition book? Access Ebook without any digging. And by having access to our ebook online or by storing it on your computer, you have convenient answers with Journal Of Biomechanics To get started finding Journal Of Biomechanics, you are right to find our website which has a comprehensive collection of books online. Our library is the biggest of these that have literally hundreds of thousands of different products represented. You will also see that there are specific sites catered to different categories or niches related with Journal Of Biomechanics So depending on what exactly you are searching, you will be able to choose ebook to suit your

own need. Thank you for reading Journal Of Biomechanics. Maybe you have knowledge that, people have search numerous times for their favorite readings like this Journal Of Biomechanics, but end up in harmful downloads. Rather than reading a good book with a cup of coffee in the afternoon, instead they juggled with some harmful bugs inside their laptop. Journal Of Biomechanics is available in our book collection an online access to it is set as public so you can download it instantly. Our digital library spans in multiple locations, allowing you to get the most less latency time to download any of our books like this one. Merely said, Journal Of Biomechanics is universally compatible with any devices to read.

Find Journal Of Biomechanics :

[fort worth isd alg 1 eoc assessment](#)

[ford xr3 1600 sport manual](#)

[ford taurus 2000 engine diagram](#)

ford spc manual

[formula renault set up guide](#)

[ford truck fuse box](#)

[formal proposal for research paper](#)

[formal languages in logic a philosophical and cognitive analysis](#)

[fordfocus mazda keymaker operating manual](#)

form national exams papers 2maths

formwork design tables

[forex automated trading file](#)

ford sport trac owners manual

ford windstar 2015 repair service manual

[forklift owners manual](#)

Journal Of Biomechanics :

Kenmore Washing Machine Repair - iFixit Repair guides and support for Kenmore washing machines. Kenmore Washer troubleshooting, repair, and service manuals. Washer repair guides and videos - Sears Parts Direct Find free washer repair guides online at Sears PartsDirect. Get step-by-step help to diagnose your problem and fix your washer fast. Kenmore Washing Machine Troubleshooting & Repair Find the most common problems that can cause a Kenmore Washing Machine

not to work - and the parts & instructions to fix them. Free repair advice! Free Online Kenmore ® Washing Machine Repair Manual Get Kenmore washer repair manuals and guides to help you diagnose and fix common issues on 500 series, 600 series, Elite Oasis and other popular models. WASHING MACHINE SERVICE MANUAL Check with the troubleshooting guide. Plan your service method by referring to ... Is the washing machine installed at an angle? Adjust the height of washing. Kenmore Service Manual | Get the Immediate PDF Download ... Kenmore Service Manual for ANY Kenmore model. We offer PDF and Booklet service and repair manuals for all brands and models. Kenmore 110 Series Washing Machine Repair - iFixit Kenmore 110 Series Washing Machine troubleshooting, repair, and service manuals ... Create a Guide. I Have This. Guides. Replacement Guides. Drive Belt. Kenmore Manuals Download kitchen, laundry, and outdoor cooking appliance manuals from Kenmore. Can't find your appliance's use and care guide? Enter your model number above ... Benson H Tongue Solutions Engineering Mechanics: Dynamics ... Solutions Manual · Study 101 · Textbook Rental · Used Textbooks · Digital Access ... Pin on Study Guides for textbooks Solutions Manual for Engineering Mechanics Dynamics 2nd Edition by Tongue ... a book with the title,'solution manual for business and financial purposes '. Solution manual for engineering mechanics dynamics 13th ... Mar 20, 2018 — Solution manual for engineering mechanics dynamics 13th edition by hibbeler ... ENGINEERING MECHANICS DYNAMICS 1ST EDITION BY TONGUE SOLUTIONS ... Full File at <https://testbanku.eu/Solution-Manual-for-...> Full file at <https://testbanku.eu/Solution-Manual-for-Engineering-Mechanics-Dynamics-2nd-Edition-by-Tongue>. 2.5. RELATIVE MOTION AND CONSTRAINTS CHAPTER 2 ... solution manual Dynamics:Analysis and Design of Systems in ... solution manual Dynamics:Analysis and Design of Systems in Motion Tongue 2nd Edition. \$38.00. 1. Add to Cart \$38.00. Description. Benson H Tongue | Get Textbooks Solutions Manual by Benson H. Tongue Paperback, 288 Pages, Published 1997 by ... Engineering Mechanics SI 2e, Engineering Mechanics: Statics SI 7e, Mechanics ... Engineering Mechanics: Dynamics - 2nd Edition Our resource for Engineering Mechanics: Dynamics includes answers to chapter exercises, as well as detailed information to walk you through the process step by ... Engineering Mechanics: Dynamics- Solutions Manual, Vol. ... Engineering Mechanics: Dynamics- Solutions Manual, Vol. 2, Chapters 17-21 [unknown author] on Amazon.com. *FREE* shipping on qualifying offers. Engineering Mechanics: Dynamics : Tongue, Benson H. Engineering Mechanics: Dynamics, 2nd Edition provides engineers with a conceptual understanding of how dynamics is applied in the field. Grade 6 FSA Mathematics Practice Test Questions The purpose of these practice test materials is to orient teachers and students to the types of questions on paper-based FSA Mathematics tests. By using. Grade 6 FSA ELA Reading Practice Test Questions The purpose of these practice test materials is to orient teachers and students to the types of questions on paper-based FSA ELA Reading tests. By using. Grade 6 FSA Mathematics Practice Test Answer Key The Grade 6 FSA Mathematics Practice Test Answer Key provides the correct response(s) for each item on the practice test. The practice questions and. 2019 FSA 6th Grade Review Practice Test 1 2019 FSA 6th Grade Review. Practice Test. 1. Page 2. 2019 FSA 6th Grade Review. Practice

Test. 2. Page 3. 2019 FSA 6th Grade Review. Practice Test. FSA - Grade 6 Math: Test Prep & Practice Final Exam Test and improve your knowledge of FSA - Grade 6 Math: Test Prep & Practice with fun multiple choice exams you can take online with Study.com. Grade 6 Mathematics Questions. Yes. No. Is the proportion of the punch that is cranberry juice the same in each of Chris's recipes given in his table? Is the proportion of the. FSA - Grade 6 Math: Test Prep & Practice Course FSA Grade 6 Mathematics Exam Breakdown ; Expressions and Equations, 30%, 18-19 questions ; Geometry, 15%, 9-10 questions. Grade 6 FSA ELA Writing Practice Test The purpose of these practice test materials is to orient teachers and students to the types of passages and prompts on FSA ELA Writing tests. FAST Practice Test and Sample Questions - Florida ... FAST Practice Test & Sample Questions for Grades 3-8 and High School. Check out Lumos Florida State Assessment Practice resources for Grades 3 to 8 students!