Master track Medical Imaging and Intervention

Size-adjustable Stent in Thoracic Endovascular Aortic Repair in case of a Type B Aortic Dissection

Group 1; Maaike Dotinga, Merel van der Stelt, Angelique van Vlaenderen, Annelies Winkelhorst, Ellis Winters, Lisanne Zwart

Abstract:
Thoracic endovascular aortic repair (TEVAR) comprises the minimal invasive placement of an endovascular stent graft in case of a type B aortic dissection. One of the problems concerning this procedure is undersizing of the stent which results in insufficient fi xation and therefore endoleaks. To face this problem, this article describes a new stent design in which the stent diameter can be varied over the whole length. This can be achieved by placing multiple thin straps of poly-ether-ether-ketone containing a pawl and strap mechanism between the exoskeleton and endograft of the stent. The materials for the latter, respectively nitinol and Teflon, are able to extent due to their confi guration and elastic properties. The stent can be placed in the same way as the current TEVAR procedure and fixation is reached via oversizing. To achieve the optimal stent size, a balloon can be placed and filled via the percutaneous approach which causes the stent to increase in diameter. This can be conducted during the first intervention or even months after its placement. More research is needed to further explore the idea of the size-adjustable stent before it can be implemented into the clinic.

Specifying type B Aortic Dissection Categories and a review on the new Imaging Technique 4D Magnetic Resonance Imaging

Group 2; Kevin Groot Lipman, Tim van Helden, Jurre Klaassen, Rutger Metselaar, Huib Ruitenbeek, Koen Verdonschot

Abstract
The treatment decision of an aortic dissection is quite difficult to make. Up to now, surgeons normally stent the whole dissected aorta. In order to find out how to improve the treatment, different studies created aortic dissection simulation models where tear size and blood pressure affect the hemodynamics of the false lumen. One of these models is purely a computational fluid dynamics (CFD) model, the other a latex phantom of the aorta. By comparing results of a computer-and a real life model, it is possible to get an insight in the usability of the computer model. Based on data of all these models, different types of dissections will be split into several predefined groups to analyse pressure characteristics in different dissection types. These distinctions may improve treatment selection.
Mathematical models can be used to get an indication of the hemodynamics of a patient. To personalize these models, input parameters should approach the hemodynamics of a patient as close as possible. With current techniques it is often difficult to estimate these parameters and with techniques such as Doppler-ultrasound they are limited to simple clinical markers. 4D MRI however, a novel imaging technique, enables the calculation of more (advanced) hemodynamic parameters. Additionally, it is a promising modality for flow visualization in the (pathologic) thoracic aorta. These parameters will improve the current models and diagnostics and thus may be able to improve treatment selection.
Keywords: 4D MRI, aortic dissection, diagnosis, imaging technique, treatment

The influence of entry closure in type B aortic dissection, a computational fluid dynamics study

Group 3; Myrthe Buser, Evelien van Genugten, Jesse van der Ouderaa, Mark Selles, Jorik Slotman, Madelon Voets

Abstract
Introduction: Type B dissection of the aorta divides the lumen of the aorta in a false and a true lumen. When performing a surgical treatment for type B dissection, TEVAR, the stent
size is essential for the outcome of the surgery. The goal of this treatment is to limit the bloodflow in the false lumen, so thrombosis is induced and the false lumen will be closed. However, stenting too far can lead to multiple complications. Methods: An algorithm with the use of MATLAB has been developed in order to find a method to predict the closing of the false lumen when the entry-point is stented. Incorporated into this algorithm are the velocity and pressure of the blood in the false lumen.
Results: The highest pressure can be found in the arch of the aorta. At the entry and re-entry points, small laminar flows can be seen. Flow between these two points is low. Pressure drops significantly when the entry point is closed. The location of entry and re-entry points influenced pressure and flow in the false lumen. A smaller length of the false lumen results in a decrease in pressure.
Conclusion: The developed algorithm seems to be adequate to predict the velocity and pressure in the false lumen. The algorithm shows a significant drop of false lumen pressure
after closure of the entry point. The pressure in the false
lumen is influenced by location and size of the entry-tear. Due to the simplicity of the model, this study is limited in terms
of comprehension of the true complicated hemodynamics of aortic dissection.
Key words: Aortic dissection type B, predictive model, MATLAB, false lumen

Addition of flow and pressure sensors to stent grafts to detect type endoleaks during EVAR and the follow-up

Group 4; Mathijs Dijselhof, Alexander Lau, Maarten Poirot, Jonas Riksen, Bas Schippers, Friso Schoffelen

Abstract

Background: Computed Tomography Angiography (CTA) is the standard imaging modality for EVAR follow-up. CTA can detect endoleaks, but utilizes radiation and nephrotoxic contrast agents. Integrating pressure and flow sensors in the stent, could enable endoleak detection during and after EVAR without any radiation or nephrotoxicity. This leads to the following research question: "Can pressure and flow sensors be added to endovascular stents, in order to improve stent placement and endoleak detection during and after EVAR?"

Methods and results: A change in pressure alters the capacitance and resonance frequency of the wireless sensor, which is displayed real-time on an external monitor. Type I and type III endoleaks are the most clinically relevant. To detect type I and type III endoleaks, the pressure sensors should be placed at the upper edge of the stent and in the excluded aneurysm sac, respectively. Flow is measurable with anemometers and ultrasound. Flow sensors should be placed around the edge of the stent and caudally oriented, enabling type I endoleak detection. Perioperatively, sensors could be utilized to confirm correct stent placement. In the follow-up, an algorithm can extract valuable parameters from the data to assess anatomical and stent development and decrease the need for follow-up CT-scans.

Discussion: Pressure sensors can reliably sense pressure in aneurysm sacs, but long-term studies have yet to be conducted. Moreover, not all pressure values can be linked to endoleak outcomes. More research is needed to resolve these issues. This also applies to flow sensors, with the added technical challenge of functionally integrating them into the stent.

Conclusion: The combination of pressure and flow sensors on endovascular stents could become a viable monitoring alternative to CTA after EVAR.

Keywords— Aneurysm sac, endoleakage, endovascular stent, false lumen, type I endoleaks, type III endoleaks

Modular custom-made and off-the-shelf stent as a hybrid treatment for type B aortic dissections

Group 5; Nienke de Laat, Chien Nguyen, Bob Nijendijk, Hanneke Pouw, Stephan Romeijn, Stefan Smorenburg

Abstract:
In patients with type B aortic dissection, endovascular treatment has become the golden standard over the past decades. During planning of an operation and the procedure, the surgeon will decide which configuration of existing stents is best suitable for the patient and only in rare, often more complex, cases a personalized stent is ordered.
Planning, manufacturing and delivery of such custom made stents requires more time and the costs are significantly higher, meaning a balance continuously has to be sought between off-the-shelf and custom made devices.
Recently, additive manufacturing (3D printing) is rapidly gaining popularity amongst many different fields including medical appliances. Additive manufacturing offers a great degree of freedom in personalization, making it ideal for complex patient cases. Time, however, is again an important factor since objects are created layer by layer, meaning that larger objects such as a complete thoracic stent are not suitable for large scale application.
We propose a modular stent, existing of a combination of off-the-shelf products and a custom-made landing zone. This results in a minimal amount of fabrication time and costs, while being personalised for the patient.

3D printed maxillary obturator based on pre-operative planning in a patient after complete maxillectomy.

Group 6; Mechteld Brasz, Jasper van der Graaf, Jane Gruisen, Michelle Simons, Bart Thomson, Beau van Woudenberg

Abstract:
A patient is presented with an adenoid cystic carcinoma in the left ethmoid bone with growth in the ductus lacrimalis. Conventional treatment consists of a maxillectomy, removing a large part of the maxilla. This can lead to disturbance of the oral functions such as breathing, speaking or articulating, deglutition or mastication. To improve these functions an obturator is positioned at the defect site. This article presents an alternative for constructing and implementing the primary and secondary obturator based on pre-operative planning and possibly 3D printing. The techniques to realize this look promising, however technological developments in the near future are necessary to make real-time printing on the OR possible.

A case study into development of a light weighted primary surgical obturator for patients with a maxillary sinus tumor of the Antoni van Leeuwenhoek hospital

Group 7; Timon ter Braak, Merle Huiskes, Floortje Jolink, Mirte Ketel, Liset Noltes, Claire van der Riet

Abstract:
The main treatment for tumors in the maxilla is surgical removal, maxillectomy. To overcome functional problems of patients who underwent maxillectomy, an patient specific obturator is created. Currently, this obturator is heavy, time consuming to make and has to be bioinert. This report focusses on creating a patient specific light weighted obturator, to replace the surgical and interim obturator. Different requirements and properties of materials and production methods are discussed. The most promising obturator is a new lightweight titanium obturator. For this, a 3D patient specific hollow model is created in MATLAB and ITK-snap.

New Approach for Maxillofacial Reconstruction using a Personalized Prosthesis

Group 9; Julian Abbing, Thijs Bussink, Rob van Dijk, Mathijs Fitski, Renée Geraats, Philippe de Rooy

Abstract
After a maxillectomy, the defect is restored with an obturator or with the free flap technique. However, these are suboptimal solutions for reconstruction of the defect created during maxillectomy. A literature research has been carried out to describe a new approach for maxillofacial reconstruction. Preoperative planning and surgical navigation allows for accurate resection areas, precise prosthesis implantation and optimal cosmetic results. The proposed biomaterial can be 3D printed and is of the polyaryletherketone family. Peroperative, Betadine or Lavasept are proposed to sterilize the oral and nasal cavity. Fixation of the prosthesis can be carried out with intermaxillary fixation screws or wires. The prosthesis can first be lined with an autologous skin graft which can later be replace with in vitro cultivated autogenous oral mucosa. As preparation before surgery and as aftercare, the chronic inflammation has to be suppressed with antibiotics. Further, movement of the prosthesis in the first three weeks after implantation should be minimized. The result of the procedure can be evaluated with a postoperative scan. The theoretical proposals give insight in a new approach for personalized maxillofacial reconstruction.
Keywords: Maxillectomy, Maxillofacial Reconstruction, Biomaterials, 3D Printed Scaffold, Tissue Regeneration, Prosthesis.

Surgical and interim obturator replacement by a 3D printed obturator

Group 10; Joosje de Bakker, Tessa Brouwer, Klijs de Koning, Lisanne Roelofs, Ilse Spenkelink, Nienke Wassenaar.

Abstract

Introduction: Treatment of a tumor in the maxilla almost always consist of a resection of the tumor, often called maxillectomy. During the resection, a big part of the maxilla is removed. The resection area has to be filled with a patient-specific designed obturator to restore the function and improve the esthetic appearance of the patient. At this moment, three different obturators are used after the operation. This article studies if the first two obturators could be replaced by one obturator which will lead to less discomfort for the patient. The 'new' obturator will be fabricated using a 3D printer, based on the segmented tumor on MRI scans. The 3D printed obturator will be made prior to the operation, so the surgeon does not have to make the obturator on view during the surgery. In this research, the process of creating the obturator is described.

Method: MRI scans of a patient are used to make a segmentation of the tumor of the patient. This segmentation will be used to eventually make a model for the 3D printer. Furthermore, literature research is done to determine the optimal 3D printing technique and material for the obturator.

Results: The main characteristics of the optimal obturator are described, such as the desired properties of the material and the desired functionality. In addition, different 3D printing techniques, sterilization techniques and materials are elaborated. The way of implementing the new obturator in the current procedure is also described.

Discussion: The procedure that is described in this article is not optimal yet. A solution has to be found to adjust the obturator when the optimal restriction lines could not be followed during the operation. The clinical relevance and the costs of the new procedure have to be studied. Moreover, it is important to survey the functionality of the obturator.