Publishable Summary for 18RPT02 adOSSIG
Developing an infrastructure for improved and harmonised metrological checks of blood-pressure measurements in Europe

Overview

This project aims to improve the reliability and accuracy of blood pressure (BP) measurements by developing an advanced oscillometric signal generator (aOSG) and by establishing new calibration procedures and services for blood pressure metrology. Furthermore, the project will establish a competence centre for blood pressure metrology and create a network in this field consisting of NMIs, DIs, surveillance bodies and medical professionals.

Need

Hypertension affects almost half of the European population and is responsible for 13 % of all non-accidental deaths. Hypertension increases the probability of stroke, heart attack and kidney diseases, causing over 22 % of all heart attacks. Reliable and accurate BP measurements using sphygmomanometers (SMs) are indispensable in the diagnostic and treatment of hypertension as its detection is very sensitive to measurement errors. Studies show that even small deviations can have critical consequences.

While the European legislation requires lengthy and costly clinical trials before a new sphygmomanometer enters the market, such trials are not performed on every manufactured device, but on single, well maintained specimens. In addition, despite the fact that periodical verifications of medical devices in use are recommended by the European Society of Hypertension, most EU countries ignore this recommendation. Only few countries adopt mandatory periodical checks for SMs in operation. Currently these checks are only performed at static pressure and check the accuracy of the pressure sensor. The algorithm used for the determination of the systolic and diastolic pressure is ignored and consequently the accuracy of the measurands themselves is never examined.

The challenges in the area of BP measurements are exacerbated by an insufficient metrology infrastructure at NMI level, where blood pressure metrology is considered of secondary importance to pressure metrology. Consequently, instead of establishing urgently needed true traceability for dynamic oscillometric instruments, only the surrogate of static pressure measurements is verified.

To rectify current situation, an aOSG that can generate oscillometric BP signals indistinguishable from real-life human signals is needed. As there are currently no procedures for testing sphygmomanometers with such a device, corresponding procedures should be defined as well. Using aOSGs for SM testing would solve the problem on the device level but the aOSGs must also be adequately calibrated. To exploit their full potential, the complete traceability chain for aOSGs needs to be established.

Objectives

The overall aim of the project is to develop sustainable metrological research capabilities to provide traceability for blood pressure measurement in Europe. This will include the development of a new advanced blood pressure oscillometric signal generator and investigation of its possible role as an absolute blood pressure standard to carry out checks of the performance of sphygmomanometers.

The specific objectives are

1. **To develop an advanced oscillometric signal generator device** with the capability of accurately reproducing pre-recorded real-life oscillometric blood pressure pulses.
2. **To define the necessary requirements and test procedures** for the newly developed advanced oscillometric signal generator to become a reference standard to establish traceability for automated sphygmomanometers.

3. **To develop a procedure for the periodic recalibration of the newly developed advanced oscillometric signal generator** at the NMI level, including defining acceptable uncertainty limits of ±1.5 mmHg or better.
4. **To engage closely with regional and European stakeholders**, including regulatory and governmental bodies, medical experts, professional medical societies, standards developing organisations, metrological committees and device manufacturers to ensure that all medical, legal and metrological requirements regarding blood pressure measuring devices are met.
5. **To develop and implement a concept for smart specialisation in the field of traceable blood pressure measurements** and to integrate this concept with similar ones for other medical devices. To establish a single joint research capacity and to develop a strategy for the perpetuation and sustainability of this new capability and a strategy for offering calibration and research services to national or international customers including NMIs/DIs. Additionally, for each internal partner, to develop an individual strategy for the long-term operation and transnational use of this joint research capacity, and for the access to its calibration and testing services from their respective countries. The individual strategies will be discussed within the consortium, to ensure that a coordinated and optimised approach to the development of traceability in this field is developed which is suitable for Europe as a whole.

Progress beyond the state of the art

The first three objectives of the project aim to progress metrological testing of sphygmomanometers beyond the state of the art by creating an advanced test device, procedures and calibration methods.

To this end, an advanced oscillometric signal generator is being developed which will be able to generate real life signals as opposed to the strictly periodic oscillometric signals generated by the current commercial blood pressure simulators. The aOSG will be tested as a possible standard for the calibration and in-depth performance checks of sphygmomanometers.

Using the developed aOSG, the consortium will then propose a procedure for in-depth dynamic testing and complex metrological checks of automated sphygmomanometers. These advanced test procedures will amend the insufficient state-of-the-art static pressure testing and will allow the evaluation of performance of the whole sphygmomanometer rather than just the ability of pressure sensor to display static pressure correctly.

It is essential to ensure a correct operation of the aOSG itself. In that sense, the project will elaborate a clear procedure for the (re)calibration of the developed aOSG as well as establish the maximum permissible errors for the device to be considered acceptable. As such, a new, dynamic pressure traceability chain will be established which will increase the trust in the proper operation of sphygmomanometers and the confidence in the measured blood pressure values.

The project aims at the establishment of joint research capacity, which will persist beyond the project lifetime and will support, promote and further develop advanced blood pressure metrology. Currently, a number of EU countries have regulations in effect requiring periodic metrological checks for professionally used SMs to ensure consistent performance in the field. The goal is to create harmonised metrological checks for blood pressure measurements to ensure a homogeneous European market.

Results

Advanced oscillometric signal generator device

An aOSG able to generate signals undistinguishable from real-life human signals has been developed. As a commercial alternative does not exist and the experience of using such a device for the verification of sphygmomanometers is lacking, relevant results will be made publicly available.

The technical and metrological specifications for the aOSG were defined early in the project. The needed components for the device were identified based on literature research and prior experience in order to ensure a reliable performance of the device, while the requirements for the software concentrated on ensuring the complex processing of the recorded data while keeping the user interface friendly.

The aOSG and the corresponding software were developed and presented at the M9 project meeting together with the developed recording unit (RU). The RU is required for the in-depth assessment of the aOSG, allowing a quantitative comparison between the input data and the data generated by the aOSG.

First tests using real-life signals collected from the patients of a cardiology clinic in the UK were successfully performed. The thorough characterisation and evaluation of the repeatability and reproducibility of the aOSG are ongoing and the results are expected by the next project meeting.

Necessary requirements and test procedures

Test procedures for dynamic testing of sphygmomanometers as well as technical and metrological requirements need to be defined in order to use the aOSG for in-depth performance checks of oscillometric sphygmomanometers. These requirements and test procedures will amend the insufficient state-of-the-art static pressure testing and will allow the evaluation of the performance of the entire components of the sphygmomanometer rather than just the pressure sensor.

Procedure for the periodic recalibrations of aOSGs

Currently, the calibration of almost every pressure instrument is carried out at static pressure. By introducing the use of aOSG for the verification of SMs, the option for a dynamic verification will be available. While this would ensure an appropriate check of SMs, it is essential that the aOSG will be properly (re)calibrated as well. As a valid calibration of such a device is currently not possible at NMI level, the development of advanced dynamic calibration procedures is one of the necessary steps to allow the aOSG to work as intended.

A thorough literature survey on available solutions for dynamic pressure with emphasis on range of the oscillometric signals and BP applications was performed. Based on the literature survey, technical and metrological requirements for the test equipment are currently being defined. Although the dynamic pressure traceability will be, as expected, a challenging task, there are no issues or obstacles at the moment and work towards this objective progresses as planned.

Concept for smart specialisation in the field of traceable blood pressure measurements

This project aims at developing and implementing smart specialisation concept (SSC) and creating a network of NMIs, DIs and universities that will be able to support and advise blood pressure metrology in Europe at all levels, from manufacturers, test offices, laboratories and market surveillance bodies to end-users, such as the medical community and patients.

Through this concept, metrology for advanced blood pressure measurements will be made accessible to a broader range of countries. This will be achieved by condensing expertise and knowledge at one site, while simultaneously making it accessible to others. A centre of excellence for blood pressure measurement (competence centre) will be established at CMI, which will be designed for the needs all European NMIs/DIs in this field who cannot or do not want to build and maintain this capacity for themselves. Additionally, each internal partner will develop an individual strategy for the long-term operation and transnational use of this joint research capacity, and for the access to its calibration and testing services from their respective countries. The individual strategies will be discussed within the consortium, to ensure that a coordinated and optimised approach to the development of traceability in this field is developed which is suitable for Europe as a whole. The SSC will be a foundation for a long-term partnership in the field of traceable blood pressure measurements, i.e. beyond the end of this project. The smart specialisation will allow the involved NMIs and DIs to optimally utilise the limited national capacities in a smart division of labour and resources.

Impact

Impact will stem from the two main goals of the project: the development of an advanced oscillometric signal generator and the establishment of the research and competence centre for blood pressure metrology. The outputs of this project will significantly progress blood pressure metrology beyond the current state of the art, improving reliability and accuracy of oscillometric blood pressure measurements achievable at all levels including NMIs, DIs, surveillance bodies, manufacturers of sphygmomanometers, medical professionals and patients.

The projects partners are actively participating in key blood pressure monitoring equipment and pressure related standardisation and legal metrology committees. Since start of the project, members of the consortium have been involved in the revision of the OIML recommendations OIML R 16-1, OIML R16-2. Members of the consortium were also highly involved in development of new technical specification ISO TS 81060-5:2020, published in February 2020 as well as the revision of the existing standards ISO 81060-2 and ISO 81060-3.

Currently, the project has 28 stakeholders from 11 countries. The list will be expanded in order to ensure that the expertise and views of the relevant players in the field will be taken into account when developing the smart specialisation concept. In addition, a close cooperation between the current project and the EMPIR JRP 16RPT03 inTENSE was initiated in order to share knowledge and expertise and in the same time to create a shared network with focus on medical device metrology.

Impact on industrial and other user communities

The development of an aOSG and corresponding advanced calibration procedures will allow easier and more affordable in-depth performance checks of automated sphygmomanometers. This will ease the development process of SMs for new and small manufacturers, offering them a chance to access the market at lower costs and thus encouraging the innovation.

The research and competence centre for blood pressure metrology planned to be established during the project will create a well-developed metrological infrastructure with advanced calibration services and will provide manufacturers with clear guidance, and hence legal certainty on how requirements can be met. Physicians and medical staff will be able to rely on the existing traceability chain, trust the measurement results are correct and methods are validated. Patients in clinics, practitioner offices, and home-care settings will have more confidence in the measured BP values, as the improved infrastructure will allow surveillance bodies and other legal entities to ensure adequate quality of the devices available on the market.

Impact on the metrology and scientific communities

The project will make metrology for advanced blood pressure measurements accessible to a broader range of countries. This will be achieved through a smart specialisation concept, by condensing expertise and knowledge at one site, while simultaneously making it accessible to others. A centre of excellence for blood pressure measurement (competence centre) will be established at CMI, which will be designed for the needs of all European NMIs/DIs in this field who cannot or do not want to build and maintain this capacity for themselves. The project will create a network for blood pressure metrology consisting of NMIs, DIs, surveillance bodies and medical professionals, and a calibration laboratory providing dynamic pressure traceability will be established. Other European NMIs, particularly emerging NMIs and DIs, which are lacking the capabilities or the resources to provide the complete traceability chain for BP measurements, will be able to serve their national customers with less demanding metrological services, while relying on the competence centre for the higher-level ones.

Impact on relevant standards

The project is actively participating in key blood pressure monitoring equipment and pressure related standardisation committees as well as international and European legal metrology organisations (e.g. ISO/TC 121/ SC3/ JWG 7, OIML TC 18 and IMEKO TC 16). This participation builds on links already established by the consortium, which is highly influential in national and international metrology and standardisation committees and will be used to facilitate greater awareness of the benefits of the project.

In the period September 2019 – January 2020, PTB was strongly involved in the revision of the OIML recommendations *OIML R 16-1 Non-invasive non automated sphygmomanometers* and *OIML R 16-2 Non-invasive automated sphygmomanometers*. R 16-2 includes details regarding testing procedures for the verification of automated sphygmomanometers using patient simulators. The two recommendations are in the committee draft stages and are awaiting the balloting results.

As the main proposer of the *ISO TS 81060-5:2020 Non-invasive sphygmomanometers - Part 5: Requirements for the repeatability and reproducibility of NIBP simulators for testing of automated non-invasive sphygmomanometers,* PTB was highly involved in the development of this new technical specification. The TS was published in February 2020. The TS will be relevant for the development of procedures for the verification of SMs by means of NIBP simulators, planned in the WP2 of the project.

In the longer term, i.e. after the end of the project, the outcomes may contribute to the revision of different normative documents (e.g. IEC 80601-2-30,OIML R 16-2, ISO TS 81060-5:2020). As PTB is the principal editor of the German "Leitfaden für die messtechnische Kontrolle von Medizinprodukten mit Messfunktion" (Guidelines for Metrological Verifications of Medical Devices with a Measuring Function), relevant project results will serve as input into this document.

Longer-term economic, social and environmental impacts

The European healthcare industry will primarily benefit from this project in the long term. The prevalence of hypertension is 44 % in Europe, which means more than 200 million adults are affected by this health problem. Thus, accurate and reliable blood pressure measurements are of crucial importance. By the end of the project, an aOSG will be developed with uncertainty of better than ±1.5 mmHg and a dynamic traceability chain will be established. Although this will not improve the accuracy of the sphygmomanometers per se, it allows cheaper complex in-depth testing of sphygmomanometers, either existing or in development. It can thus be expected that the accuracy of a sphygmomanometer can be maintained without significant deterioration over the whole production and lifetime cycle of the device; a guarantee which cannot possibly be given today. Cautiously, assuming that for only 1 % of the patient misdiagnoses can be avoided in the future, the direct benefits of the project can be quantified as:

- 2 million EU citizens who will be spared a false positive or false negative diagnosis,
- 370 M€ per year which will be saved for the EU healthcare systems by avoiding the costs for unnecessary medication of healthy subjects and the even higher costs for undetected and untreated hypertension (estimated from 196 B€/a total costs for cardiovascular diseases in the EU in 2009, 53 % of which are treatment costs, and a ~36 % share for hypertension treatment).

<table>
<tr><td colspan="2">Project start date and duration:</td><td>01 June 2019, 36 months</td></tr>
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<tr><td>Internal Funded Partners:
1. CMI, Czech Republic
2. BEV-PTP, Austria
3. GUM, Poland
4. IMBiH, Bosnia and Herzegovina
5. IPQ, Portugal
6. NSAI, Ireland
7. PTB, Germany
8. SMU, Slovakia</td><td>External Funded Partners:
9. UL, Slovenia</td><td>Unfunded Partners:</td></tr>
<tr><td colspan="3">RMG: -</td></tr>
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