

Long Term Project Report : Interim/Final

Summary Page

1. Beamtime Used

Please give a short summary of progress for each scheduling period for which beamtime has been allocated/used :

Scheduling period	Beamline(s) Used	Shifts Used	Summary of results obtained
2006 /II	ID17	15	MD238/1: Distribution of ventilation in allergen sensitized rabbits
2007 /I	ID17	17 17	MD238/2: Distribution of ventilation after bronchoconstriction in allergen sensitized rabbits MD238/3: Effects of tobacco smoke on airway responses
2008 /II	ID17	15	MD238/4: High-resolution functional imaging of rats
2009 /I	ID17	15	MD238/5: High-resolution functional imaging of bronchoconstriction in allergen sensitized rats
2009 /II	ID17	15	MD238/6: Changes in ventilation after lung injury
2010 /I	ID17	15	MD429/1: Imaging of aerosol deposition in the lungs by iodine
2010 /II	ID17	15	MD429/2: Aerosol deposition after bronchial provocation

2. Resources Provided by User team (financial, personnel, technical...):

- Forced Oscillation Technique device was included in the lung imaging setup.
- Small animal KES imaging using FreLon camera and ventilator for small animals
- Combined Xe and Iodine KES imaging
- During the LTP period, Dr. Liisa Porra from our group worked at the ESRF as visiting scientist, and participated in other beamline projects when needed.

3. Technical and Scientific Milestones Achieved (in relation to the milestones identified in the original proposal):

Year 1

Milestones:

- *Ventilation distributions in normal and sensitized animals without drug challenge*
- *Effects of bronchial challenge in normal and sensitized animals*
 - Changes on distribution of ventilation was studied during MD238/1,2 and 4, 5 and 6, and results are presented in references 1, 5, 6, 10 and 11

Year 2

Milestones:

- *Effects of different drug and air impurity doses on ventilation in normal and sensitized animals*
- *Controls of the previous studies with respect to the results of mathematical modeling of ventilation distributions*

- Changes in ventilation after tobacco smoke provocation performed during MD238/3, presented in reference 7
- Ventilation injury study performed during MD238/6 presented in reference 9
- Modeling and technical results published in references 2 and 8

Year 3

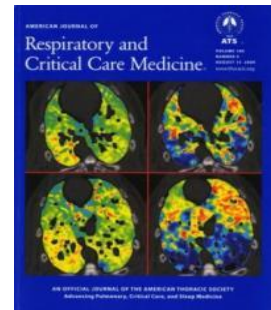
Milestones:

- *Effects of medication on asthmatic animals*
- *Controls of the preceding experiments*
 - Aerosol distribution studies performed in MD429/1 and MD429/2, and results are presented in reference 12

4. List of publications directly resulting from beamtime used for this Long Term Project:

1. Bayat S, Porra L, Suhonen H, Janosi T, Strengell S, Habre W, Petak F, Hantos Z, Suortti P, Sovijärvi A. Imaging of Lung Function Using Synchrotron Radiation Computed Tomography: What's New? *Eur J Radiol*. 2008; 68S: S78–S83. (IF 2.941)
2. Suhonen H, Porra L, Bayat S, Sovijärvi ARA and Suortti P. Simultaneous in vivo synchrotron radiation computed tomography of regional ventilation and blood volume in rabbit lung using combined K-edge and temporal subtraction. *Phys Med Biol* 2008 53: 775-791. (IF 3.057)
3. Sovijärvi ARA, Porra L, Suortti P. A new method for assessment of lung function disturbances - subtraction imaging with synchrotron radiation (in Finnish), Review. *Duodecim* 2008;124:271-8.
4. Adam JF, Bayat S, Porra L, Elleaume H, Estève F, and Suortti P. Quantitative functional imaging and kinetic studies with high-Z contrast agents using synchrotron radiation computed tomography. *Clin Exp Pharmacol Physiol*. 2009 Jan;36(1):95-106. (IF 1.960)
5. Bayat S, Porra L, Suhonen H, Suortti P and Sovijärvi ARA. Paradoxical conducting airway response and heterogeneous regional ventilation after histamine inhalation in healthy anaesthetized rabbits studied by synchrotron radiation CT. *J Appl Physiol* 2009; 106: 1949–1958. (IF 4.235)
6. Bayat S, Strengell S, Porra L, Janosi T, Petak F, Suhonen H, Suortti P, Hantos Z, Sovijärvi A, and Habre W. Metchacholine and ovalbumin challenges assessed by forced oscillations and synchrotron lung imaging. *Am J Resp Crit Care Med*. 2009 Aug 15;180(4):296-303. (IF 10.191)

(Study by Bayat et al, 2009 (6), was published in the top journal of the field and representative images of the study were selected to the cover page of the journal)



7. Porra, L., Petak, F., Strengell, S., Neitola, K., Janosi, T. Z., Suhonen, H., Suortti, P., Sovijarvi, A. R. A., Habre, W. and Bayat, S. Acute cigarette smoke inhalation blunts lung responsiveness to methacholine and allergen in rabbit: differentiation of central and peripheral effects. *Am J Physiol -Lung Cell Mol Physiol*. 2010; 299: 242-251. (IF 4.137)
8. Porra L. Suhonen H, Suortti P, Sovijärvi ARA, Bayat S. Effect of PEEP on regional ventilation distribution following airway constriction in rabbit studied by synchrotron radiation imaging. *Crit Care Med*. 2011 Jul;39(7):1731-8. (IF 6.254)
9. Bayat S, Porra L. Albu G, Suhonen H, Strengell S, Suortti P, Sovijärvi A, Petak F and Habre W. Combined analyses of lung volume, ventilation heterogeneity and respiratory mechanics distinguishes hyperinflation and recruitment in lung injury. Submitted to *Anesthesiology* 2011. (IF 5.486)
10. Layachi S, Porra L, Albu G, Trouillet N, Suhonen H, Petak F, Sevestre H, Suortti P, Sovijärvi A, Habre W and Sam Bayat S. Role of cellular effectors in the emergence of ventilation defects during allergic bronchoconstriction. Manuscript in preparation, 2012.
11. Strengell S, Porra L, Suhonen H, Suortti P, Bayat S, Sovijärvi A. Heterogeneity of bronchoconstriction by intravenous and inhaled methacholine in anaesthetized rabbit. Manuscript in preparation, 2012.
12. Bayat et al. Feasibility of K-edge subtraction synchrotron imaging for the measurement of regional aerosol deposition, lung ventilation and airway morphology in rabbit. Manuscript in preparation 2012.



	Experiment title: Functional imaging of the effects of inhaled drugs and air pollution particles on regional ventilation in healthy and asthmatic animals	Experiment number: MD238 / MD429
Beamline: ID17	Date of experiment: from: II/2006 to: II/2010	Date of report: 19.12.2011
Shifts: 8*(15-17)	Local contact(s): Christian Nemoz, Liisa Porra	<i>Received at ESRF:</i>
Names and affiliations of applicants (* indicates experimentalists): <p> Anssi Sovijärvi Helsinki University Central Hospital, and University of Helsinki, Finland * Sam Bayat University of Amiens, France * Skander Layachi * Liisa Porra University of Helsinki, Finland * Kimmo Neitola * Pyry Sipilä * Satu Strengell * Heikki Suhonen * Pekka Suortti * Walid Habre Geneva University Central Hospital, Switzerland * Gergely Fodor * Tibor Janosi Zoltan Hantos University of Szeged, Hungary * Ferenc Petak * Gergely Albu * Enikő Lele </p>		

Report:

This is the final report of Long Term Project MD238 and its extension MD429. The proposal MD238 was accepted originally for the beamtime allocation periods 2006/II – 2008/I. Due to reconstruction of ID17, the use of beamtime was interrupted for one year. Extension MD429 for third year and 30 shifts was accepted in 2009.

Beamline	Shifts	Experiment	Starting Date	Finishing Date
ID17	15	MD238/1	07 Dec 2006	12 Dec 2006
ID17	17	MD238/2	05 Feb 2007	12 Feb 2007
ID17	17	MD238/3	11 Jul 2007	16 Jul 2007
ID17	15	MD238/4	04 Dec 2008	09 Dec 2008
ID17	15	MD238/5	07 May 2009	12 May 2009
ID17	15	MD238/6	10 Dec 2009	15 Dec 2009
ID17	15	MD429/1	6 May 2010	11 May 2010
ID17	15	MD429/2	9 Dec 2010	14 Dec 2010

Milestones in the LTP project plan:

In the LTP proposal following schedule was planned:

Year	Shifts	Planned experiments
Year 1	30	Ventilation distributions in normal and sensitized animals without drug challenge
	15	Effects of bronchial challenge in normal and sensitized animals (pilot experiments)
Year 2	30	Effects of different drug and air impurity doses on ventilation in normal and sensitized animals
	15	Controls of the previous studies with respect to the results of mathematical modeling of ventilation distributions
Year 3	30	Effects of medication on asthmatic animals
	15	Controls of the preceding experiments

Details of main scientific findings:

Following the outline of the LTP for the first 2 years, the 3 first experiments concentrated on acute response of healthy and chronically ill animals to drugs and air impurities, and to method developments. In order to open up possibilities to use various experimental models of diseases, 4th and 5th experiment were used to develop high-resolution imaging setup. 6th experiment was devoted to understand the effect of Positive End Expiratory Pressure (PEEP), which is used to improve ventilation uniformity in asthmatic patients or in respiratory distress patients under mechanical ventilation Last 2 experiment (MD429/1 and 2) were used to image the deposition of inhaled aerosol in the lungs. The results are summarized below.

1. Mch and allergen provocation was studied in the first 3 experiments of the LTP project MD238/1 and /2 and /4. The aim of these studies was to use new asthma model using sensitized rabbits, and compare images obtained with synchrotron radiation with results on overall lung mechanics obtained with the forced oscillation technique (FOT) (1). This animal model was used to study the effects of Mch on the airways by using two ways of administration (i.v. and inhaled) and to compare those with the effects of allergen provocation administered by i.v.(figure 1). The main finding was that iv. Mch induced constriction mainly in large bronchi but i.v. allergen in peripheral airways with markedly heterogeneous ventilation (11). Instead, inhaled Mch aerosol provoked similar peripheral airway response as i.v. allergen but with different mechanisms. A secondary finding was a strong association between the airway and tissue mechanical responses obtained by low frequency respiratory system impedance data (FOT) and corresponding imaging parameters by synchrotron radiation. The findings were published in AJRCCM by Bayat et al, 2009 (6).

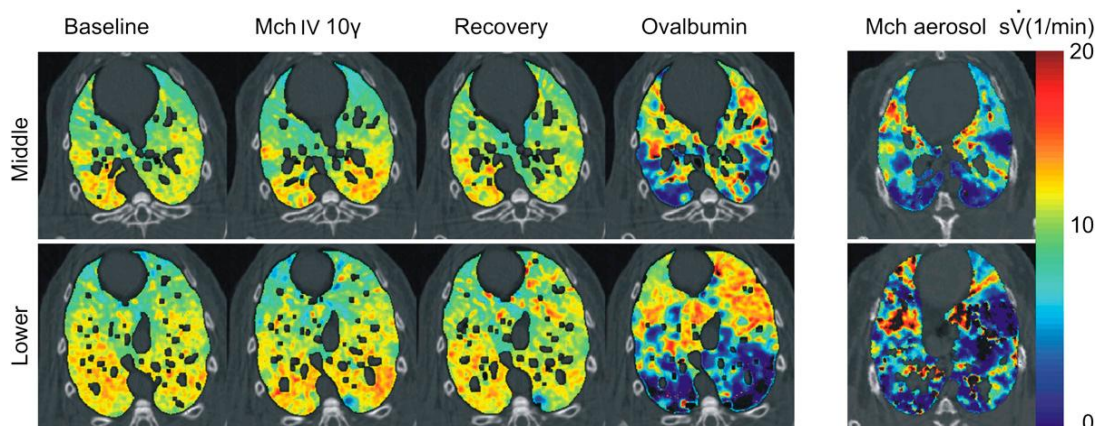


Figure 1 (from ref 6): *Left panel: images of specific ventilation in one representative sensitized rabbit at baseline, during methacholine (Mch; $\mu=\mu\text{g}/\text{kg}/\text{min}$) infusion, on recovery, and after ovalbumin provocation. Right panel: images of regional ventilation in one representative control rabbit after Mch aerosol inhalation.*

- The effects of acute tobacco smoke inhalation were investigated in the third experiment MD238/3. We studied the effects of acute tobacco smoke provocation on the airways before and after Mch and allergen challenge in sensitized rabbits by synchrotron imaging and forced oscillations (FOT). Contrary to expectations, smoke induced some dilatation in large bronchi and attenuated the bronchoconstrictive effect of Mch and also that of allergen in large bronchi, but did not blunt peripheral airway constriction to allergen (Fig 2). We concluded that the mainstream of cigarette smoke may contain short-term inhibitory components acting primarily on central airways inhibiting smooth muscle constriction response to specific (allergen) and non-specific (Mch) stimuli. These unexpected results were published in American Journal of Physiology by Porra et al. 2010 (7). This finding may partly explain why the prevalence of smoking in asthmatics is higher than in the general population.

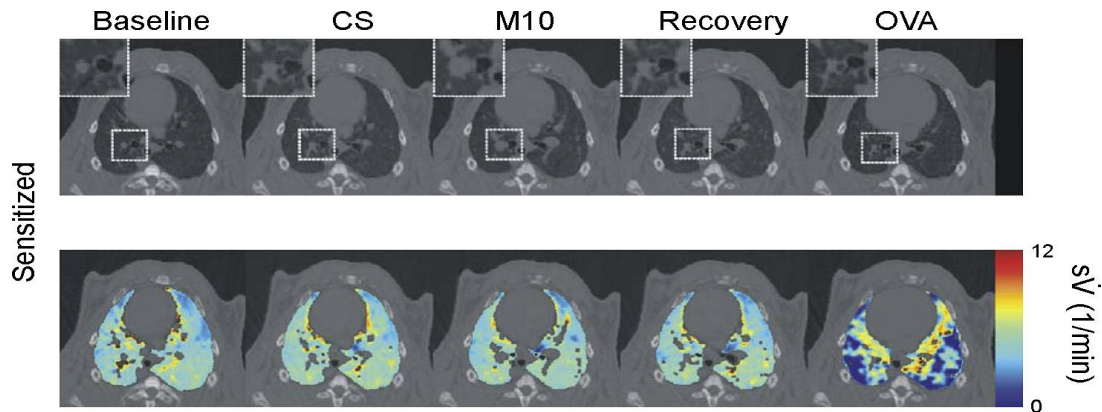


Figure 2 (from ref 7): Sensitized: mono-energetic CT images (top row) showing the central airway cross-section with 1 airway magnified (box) in the midthoracic image slice and specific ventilation images (bottom row) in 1 representative sensitized rabbit at baseline, following exposure to smoke from the 4th cigarette (CS4), during methacholine infusion of 10 $\mu\text{g}/\text{kg}/\text{min}$, upon recovery and after ovalbumin provocation (OVA).

- The methods of mechanical ventilation and physiological monitoring in KES+FOT experiments were applied for rats in the 4th and 5th experiment MD238/4 and /5 (figure 3). In sensitized rats we studied the association of local airway inflammation with the ventilation defect areas. Increased number of certain inflammatory cells in the airway walls were localized in areas of decreased specific ventilation or ventilation defects. Thus, we discovered a significant role of cellular effectors in the emergence of patchy ventilation defects during allergic bronchoconstriction. The finding has a clinical impact in diagnosis and treatment of asthma. This work will be submitted to AJRCCM 2011 Layachi et al. 2011 (10).

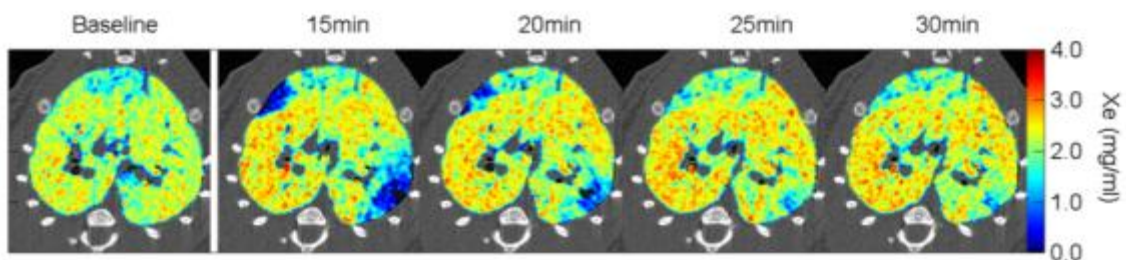


Figure 3 (from ref 10): High resolution KES images in one representative animal in upright position. Quantitative Xe-density images. Following OVA, clustered ventilation defects emerge (blue).

4. We have shown recently that moderate PEEP improves the ventilation uniformity and opens collapsed lung zones in anaesthetized rabbits during asthmatic bronchoconstriction without significant overdistension of the lungs. The findings which have clinical importance in critical care were published in Critical Care Medicine (8). Experimental model mimicing respiratory distress in premature neonates (broncho-alveolar lavage,BAL) was used in the 6th experiment of the project MD238/6 (figure 4). BAL removes surfactant from the alveoli and may cause alveolar and bronchiolar collapse. This pathologic condition often requires mechanical ventilation after birth. We used this model to study the effect of different PEEP levels on distribution of ventilation , lung volumes and tissue densities after BAL. Some optimal PEEP levels were found. Better understanding of the effects of PEEP on ventilation helps to plan those treatments. This work has been submitted to Anaesthesiology 2011 (9).

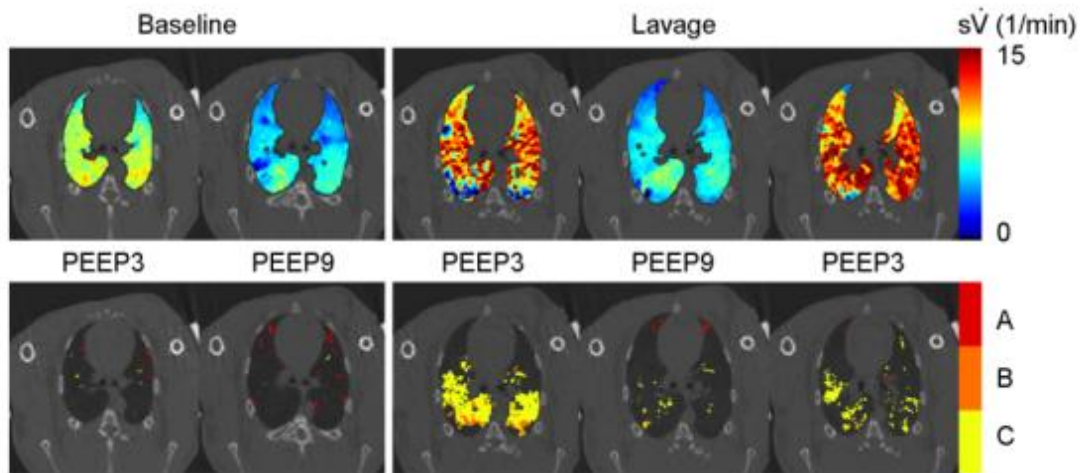


Figure 4 (from ref 9): Images showing the distribution of specific ventilation (sV ; top row) and tissue density (D ; bottom row) in a mid-thoracic image slice in one representative animal. Bottom panel depicts lung density with overdistended areas in red(A), collapsed, high density regions depicted in orange (B), and in yellow those areas that are ventilated well despite of decreased gas space (C).

5. A new approach was to develop a method to image deposition of inhaled aerosol, which is a common way to administer asthma drugs. In 7th and 8th experiments MD429/1 and /2 we used KES imaging at iodine K-edge to image iodine containing aerosol distribution in the lungs (2,3) This distribution was compared with the simultaneous distribution of ventilation imaged by xenon as contrast agent (Fig 5). The deposition of inhaled aerosol in the lungs was asymmetric and very heterogeneous even in healthy animals. The finding may partly explain the heterogeneous bronchoconstriction induced by Mch aerosol found earlier and suggests a new approach for the clinical treatment methods of asthma with inhaled drugs. Results will be fully analyzed and published later (12).

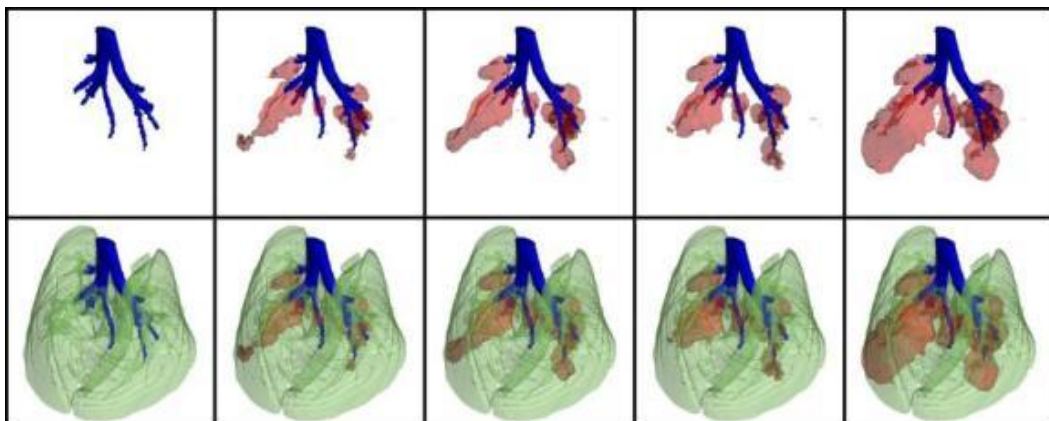


Figure 5 (from ref 12): Time series of iodine aerosol distribution in rabbit lungs. Blue: Airways. Red: Iodine aerosol. Green: Lung tissue.

Technical accomplishments and benefits

- Forced Oscillation Technique device was included in the lung imaging setup.
- Small animal KES imaging using FreLon camera and ventilator for small animals
- Combined Xe and Iodine KES imaging
- During the LTP period, Dr. Liisa Porra from our group worked at the ESRF as visiting scientist, and participated in other beamline projects when needed.

Other publications

1. **Bayat S, Strengell S, Porra L, Janosi T, Petak F, Suhonen H, Suortti P, Hantos Z, Sovijärvi A, and Habre W.** Metchacholine and ovalbumin challenges assessed by forced oscillations and synch-rotron lung imaging. ESRF Highlights 2009. <http://www.esrf.fr/UsersAndScience/Publications/Highlights/>
2. **Bayat et al.** Physicians picture ventilation pattern in a model of asthma. ESRFnews Dec 2009 No 52. <http://www.esrf.fr/UsersAndScience/Publications/Newsletter/>

Publications from MD238 and 429 experiments:

1. **Bayat S, Porra L, Suhonen H, Janosi T, Strengell S, Habre W, Petak F, Hantos Z, Suortti P, Sovijärvi A.** Imaging of Lung Function Using Synchrotron Radiation Computed Tomography: What's New? *Eur J Radiol.* **2008**; 68S: S78–S83. (IF 2.941)
2. **Suhonen H, Porra L, Bayat S, Sovijärvi ARA and Suortti P.** Simultaneous *in vivo* synchrotron radiation computed tomography of regional ventilation and blood volume in rabbit lung using combined K-edge and temporal subtraction. *Phys Med Biol* **2008** 53: 775-791. (IF 3.057)
3. **Sovijärvi ARA, Porra L, Suortti P.** A new method for assessment of lung function disturbances - subtraction imaging with synchrotron radiation (in Finnish), Review. *Duodecim* **2008**;124:271-8.
4. **Adam JF, Bayat S, Porra L, Elleaume H, Estève F, and Suortti P.** Quantitative functional imaging and kinetic studies with high-Z contrast agents using synchrotron radiation computed tomography. *Clin Exp Pharmacol Physiol.* **2009** Jan;36(1):95-106. (IF 1.960)
5. **Bayat S, Porra L, Suhonen H, Suortti P and Sovijärvi ARA.** Paradoxical conducting airway response and heterogeneous regional ventilation after histamine inhalation in healthy anaesthetized rabbits studied by synchrotron radiation CT. *J Appl Physiol* **2009**; 106: 1949–1958. (IF 4.235)
6. **Bayat S, Strengell S, Porra L, Janosi T, Petak F, Suhonen H, Suortti P, Hantos Z, Sovijärvi A, and Habre W.** Metchacholine and ovalbumin challenges assessed by forced oscillations and synchrotron lung imaging. *Am J Resp Crit Care Med.* **2009** Aug 15;180(4):296-303. (IF 10.191)
7. **Porra, L., Petak, F., Strengell, S., Neitola, K., Janosi, T. Z., Suhonen, H., Suortti, P., Sovijarvi, A. R. A., Habre, W. and Bayat, S.** Acute cigarette smoke inhalation blunts lung responsiveness to methacholine and allergen in rabbit: differentiation of central and peripheral effects. *Am J Physiol -Lung Cell Mol Physiol.* **2010**; 299: 242-251. (IF 4.137)
8. **Porra L, Suhonen H, Suortti P, Sovijärvi ARA, Bayat S.** Effect of PEEP on regional ventilation distribution following airway constriction in rabbit studied by synchrotron radiation imaging. *Crit Care Med.* **2011** Jul;39(7):1731-8. (IF 6.254)
9. **Bayat S, Porra L, Albu G, Suhonen H, Strengell S, Suortti P, Sovijärvi A, Petak F and Habre W.** Combined analyses of lung volume, ventilation heterogeneity and respiratory mechanics distinguishes hyperinflation and recruitment in lung injury. Submitted to *Anesthesiology* 2011. (IF 5.486)
10. **Layachi S, Porra L, Albu G, Trouillet N, Suhonen H, Petak F, Sevestre H, Suortti P, Sovijärvi A, Habre W and Sam Bayat S.** Role of cellular effectors in the emergence of ventilation defects during allergic bronchoconstriction. *Manuscript in preparation*, 2012.
11. **Strengell S, Porra L, Suhonen H, Suortti P, Bayat S, Sovijärvi A.** Heterogeneity of bronchoconstriction by intravenous and inhaled methacholine in anaesthetized rabbit. *Manuscript in preparation*, 2012.
12. **Bayat et al.** Feasibility of K-edge subtraction synchrotron imaging for the measurement of regional aerosol deposition, lung ventilation and airway morphology in rabbit. *Manuscript in preparation* 2012.

Conference presentations:

1. S. Bayat, L. Degrugilliers, L. Porra, G. Albu, H. Suhonen, S. Strengell, G. Fodor, F. Petak, P. Suortti, W. Habre, A. R. A. Sovijärvi. K-edge subtraction (KES) synchrotron imaging allows quantitative measurement of regional aerosol deposition, lung ventilation and airway morphology in rabbit. **European Respiratory Society annual congress 2011**, 24-28.9.2011, Amsterdam, Netherlands. Presentation (abstract #4876).
2. S. Strengell, S. Bayat, L. Degrugilliers, L. Porra, G. Albu, H. Suhonen, G. Fodor, F. Petak, P. Suortti, W. Habre and A.R.A Sovijärvi: Quantitative imaging of aerosol deposition, ventilation and lung morphology using K-edge subtraction, **XLV Nordic Lung Conference**, 9-11.6.2011. Poster (abstract page 30).
3. A. Sovijärvi et al. A new method for functional imaging of lungs and airways- synchrotron radiation with xenon. **Annual Meeting of the Finnish Society of Clinical Physiology**. April 2011. Presentation.
4. Anssi Sovijärvi. Biomedical beamline in ESRF- Quantitative airway and pulmonary function imaging with high spatial resolution. **Workshop on Nordic Biomedical Beamline at MAX-IV**. 15.11.2010, Lund, Sweden. Presentation
5. S. Strengell, L. Porra, P. Suortti, ARA. Sovijarvi. Effect of positive end expiration pressure on ventilation heterogeneity after bronchoalveolar lavage. **Finnish Respiratory Society Progress Report 2010**, 12.11.2010, Helsinki, Finland. Presentation.
6. ARA Sovijärvi. New method for lung function studies – subtraction imaging with Synchrotron radiation. **Workshop of the Finnish Clinical Physiology Society**. 4.11. 2010, Tampere, Finland. Presentation.
7. S. Bayat, L. Porra, G. Albu, H. Suhonen, S. Strengell, P. Suortti, A. Sovijärvi, W. Habre. Moderate PEEP improves ventilation heterogeneity with minimal overdistension in lavage-induced surfactant depletion in rabbits: a synchrotron imaging study. **European Respiratory Society annual congress 2010**, 18-22.9.2010, Barcelona, Spain. Poster.
8. G. Albu, L. Porra, F. Petak, H. Suhonen, S. Strengell, A. Sovijärvi, P. Suortti, S. Bayat, W. Habre. Changes in lung volume with PEEP following surfactant depletion in rabbits assessed by helium wash-out technique and synchrotron imaging. **European Respiratory Society annual congress 2010**, 18-22.9.2010, Barcelona, Spain. Poster.
9. Dept. of clinical physiology and nuclear medicine, Helsinki University Hospital. Regional lung function in experimental asthma studied by synchrotron radiation imaging (SRI) and forced oscillation technique (FOT). **Scientific Symposium**, 24.8.2010, Helsinki, Finland. Several presentations.
10. S. Bayat, L. Porra, G. Albu, S. Layachi, F. Petak, P. Suortti, Z. Hantos³, A.R.A. Sovijärvi, W. Habre. Airway Response to Inhaled Allergen Assessed by High-Resolution Synchrotron Imaging and Forced Oscillation Technique in Sensitized Brown Norway Rat. **American Thoracic Society international conference 2010**, 14-19.5.2010, New Orleans, USA. Poster
11. L. Porra, S. Layachi, A.R.A. Sovijärvi, P. Suortti, S. Bayat. High-resolution in-vivo synchrotron imaging of lung structure and regional ventilation in rat using the K-edge subtraction technique. **American Thoracic Society international conference 2010**, 14-19.5.2010, New Orleans, USA. Presentation (#2896).
12. L. Porra, S. Bayat, S. Strengell, S. Layachi, ARA. Sovijärvi, P. Suortti. High-resolution *in-vivo* imaging of lung structure and function using K-edge subtraction technique. **Medical Applications of Synchrotron Radiation 2010**, 15-18.2.2010, Melbourne, Australia. Presentation (abstract #124).
13. S. Bayat, S. Strengell, H. Suhonen, L. Porra, P. Suortti, A.R.A. Sovijarvi. Distinctive Bronchoconstriction Induced by Intravenous or Inhaled Methacholine in Rabbits Studied by Synchrotron Radiation CT. **American Thoracic Society international conference 2009**, 15-20.5.2009, San Diego, USA. Poster [Publication Page: A5588].
14. S. Bayat, L. Porra, F. Petak, T.Z. Janosi, D. Bertrand, A. Sovijarvi, P. Suortti, H. Suhonen, S. Strengell, K. Neitola, M. Sipila, L. Laakso, Z. Hantos, W. Habre. Mechanisms of Altered Airway Mechanics Following Acute Cigarette Smoke Inhalation in Rabbits. **American Thoracic Society international conference 2009**, 15-20.5.2009, San Diego, USA. Poster [Publication Page: A2439].
15. T. Janosi, F. Petak, L. Porra, S. Bayat, H. Suhonen, S. Strengell, K. Neitola, M. Sipilä, L. Laakso, P. Suortti, Z. Hantos, W. Habre, A. Sovijärvi. Bronchodilation following acute cigarette smoke exposure in rabbits assessed by forced oscillation technique and K-edge subtraction imaging. **European Respiratory Society annual congress 2008**, 4-8.10.2008, Berlin, Germany. Presentation 4432.

16. F. Peták, Z. Hantos, L. Porra, P. Suortti, A. Sovijarvi, T. Jánosi, W. Habre: Functional and structural changes in the lungs following methacholine provocations and allergic reactions in sensitized rabbits. **Meeting of the Hungarian Synchrotron Committee**, Hungarian Academy of Sciences, 7.5.2008. Hungary. Presentation.
17. S. Strengell et al. Functional Imaging of Regional Airway and Ventilation Response to Intravenous Allergen and Methacholine Studied by Synchrotron Radiation CT in a Rabbit Model of Asthma. **14th Congress SSCPNM-2008**. 13-15.2.2008, Lillehammer, Norway. Presentation.
18. S. Bayat, L. Porra, S. Strengell, H. Suhonen, T. Janosi, F. Petak, W. Habre and A.R. Sovijärvi. Functional Localization of The Effects Of Allergen And Methacholine Studied By S.R.C.T. In Rabbit. **Biomedical Engineering Society annual meeting 2007**. 26-29.9.2007, Los Angeles, USA. Invited presentation 353.
19. T. Janosi, L. Porra, S. Bayat, A. Sovijarvi, P. Suortti, H. Suhonen, S. Strengell, F. Petak, Z. Hantos, W. Habre. Correlation between respiratory mechanical and structural changes in sensitized rabbits: effects of methacholine and allergen administrations. **European Respiratory Society annual congress 2007**, 15-19.9.2007, Stockholm, Sweden. Electronic poster E1636.
20. S. Strengell, L. Porra, H. Suhonen, T. Janosi, S. Bayat, F. Petak, Z. Hantos, W. Habre, P. Suortti, A. Sovijärvi. Functional localization of airway and lung ventilation effects of allergen and methacholine challenge studied in rabbit by synchrotron radiation. **European Respiratory Society annual congress 2007**, 15-19.9.2007, Stockholm, Sweden. Presentation 2645.
21. S. Bayat, L. Porra, H. Suhonen, T. Janosi, S. Strengell, W. Habre, F. Petak, Z. Hantos, P. Suortti, A. Sovijärvi. Imaging of Lung Function Using Synchrotron Radiation Computed Tomography: What's New? **Medical Applications of Synchrotron Radiation 2007**, 26-30.8.2007, Saskatoon, Canada. Presentation.
22. L. Porra, S. Bayat, S. Strengell, H. Suhonen, T. Janosi, F. Petak, Z. Hantos, W. Habre, P. Suortti, A. Sovijärvi. Localization of Airway and Lung Ventilation Effects of Intravenous Allergen and Methacholine Challenge Studied by Synchrotron Radiation. **Medical Applications of Synchrotron Radiation 2007**, 26-30.8.2007, Saskatoon, Canada. Presentation.