

# URINARY NEUTROPHIL GELATINASE-ASSOCIATED LIPOCALIN AND CREATININE SERUM BPH PATIENTS WITH ACUTE URINE RETENTION TO DETECT KIDNEY FUNCTION DISORDERS

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## ABSTRACT

**Objective:** The main objective of this study was to determine renal function in patients with Benign Prostate Hyperplasia (BPH) in acute urinary retention period and two weeks after catheter insertion using creatinine serum and urinary Neutrophil Gelatinase-Associated Lipocalin (NGAL) biomarker parameters. **Materials & Method:** This is an observational co-hort study conducted in patients with BPH with acute urinary retention who came to Soetomo General Hospital, Surabaya. All the patients underwent laboratory investigation that were urinary NGAL and creatinine serum, marker of renal function. **Result:** The mean creatinine serum of 31 samples when retention phase was  $1.6 \pm 0.9$  mg/dL and it decreased after 2 weeks of urinary catheter insertion ( $1.46 \pm 0.89$  mg/dL). Mean urinary NGAL level when retention phase was  $308.1 \pm 244.8$  ng/dL, and after 2 weeks after urinary catheter insertion it decreased to  $158.5 \pm 123.3$  ng/dL. There was significant decreasing creatinine serum and urinary NGAL levels in patients with BPH and acute urinary retention in the retention phase 2 weeks after urinary catheter insertion, with  $p$  value  $< 0.006$  and  $< 0.0001$ , respectively. There was no significant correlation between the duration of retention and urinary retention volume ( $p > 0.05$ ). **Conclusion:** There was a significant decreasing creatinine serum and urinary NGAL levels in patients with BPH and acute urinary retention in retention phase and two weeks after urinary catheter insertion. There was no significant correlation between the urinary NGAL and creatinine serum and the duration of retention and urinary retention volume.

**Keywords:** Neutrophil gelatinase-associated lipocalin, creatinine serum, benign prostate hyperplasia, acute urinary retention.

## ABSTRAK

**Tujuan:** Tujuan utama dari penelitian ini adalah mengetahui fungsi ginjal pasien Benign Prostate Hyperplasia (BPH) saat retensi dan dua minggu setelah pemasangan kateter menggunakan parameter serum kreatinin dan biomarker Neutrophil Gelatinase-Associated Lipocalin (NGAL) urine. **Bahan & Cara:** Studi observasional ko-hort yang dilakukan terhadap sampel pasien BPH dengan retensi urine akut yang datang ke RSUD Dr. Soetomo, Surabaya. Pasien dilakukan pemeriksaan marker gangguan fungsi ginjal NGAL urine dan serum kreatinin saat retensi dan dua minggu setelah pemasangan kateter. Data akan dianalisa secara deskriptif maupun analitik. **Hasil:** Rerata kreatinin 31 sampel penelitian saat retensi  $1.6 \pm 0.9$  mg/dl dan rerata kadar menurun setelah dua minggu pemasangan kateter  $1.46 \pm 0.89$  mg/dl. Rerata NGAL urine saat retensi  $308.1 \pm 244.8$  ng/dl dan setelah dua minggu pemasangan kateter menurun menjadi  $158.5 \pm 123.3$  ng/dl. Terjadi penurunan signifikan kadar serum kreatinin dan NGAL urine pasien BPH retensi urin akut saat retensi dan setelah dua minggu pemasangan kateter dengan nilai  $p$  masing-masing adalah  $p < 0.006$  dan  $p < 0.0001$ . Kadar serum kreatinin dan NGAL urine tidak memiliki hubungan korelasi yang signifikan dengan lama retensi dan volume urine retensi ( $p > 0.05$ ). **Simpulan:** Terdapat penurunan signifikan kadar serum kreatinin dan NGAL urine pasien BPH dengan retensi urin akut saat retensi dan dua minggu setelah pemasangan kateter. Kadar NGAL urine dan serum kreatinin saat retensi tidak memiliki korelasi yang signifikan dengan lama retensi dan volume urine retensi.

**Kata kunci:** Neutrophil gelatinase-associated lipocalin, serum kreatinin, benign prostate hyperplasia, retensi urine akut.

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## INTRODUCTION

Benign Prostate Hyperplasia (BPH) is a nodular enlargement caused by proliferation of stromal and epithelial prostate gland.<sup>1</sup> The prevalence of BPH increases with age. Sixty percent of men over 50 years old will experience BPH.<sup>1</sup>

Acute urinary retention is one of serious complications on BPH. There are 1.3-8% patients who get acute urinary retention as a consequence of BPH.<sup>2-5</sup> Acute urinary retention is defined as inability to void spontaneously with lower abdominal pain due to bladder distention.<sup>6-10</sup> The volume or urine in acute urinary retention widely varies.<sup>11</sup>

Bladder outlet obstruction due to BPH results in voiding restriction.<sup>12</sup> The high intravesical pressure will be transmitted in upper urinary tract resulting in high intratubular pressure. This condition will decrease blood flow to kidney and lower glomerular filtration rate (GFR).<sup>13,14</sup> The prevalence of kidney dysfunction in patients with BPH and acute urinary retention widely varied.<sup>15,16</sup>

The gold standard diagnostic tool which is used to evaluate kidney function is inulin and radioisotope clearance. Both of them are not routinely used in acute condition due to impractical, invasive, and not highly available.<sup>17</sup> Nowadays, creatinine level is used as gold standard diagnostic tool to assess renal function.<sup>17,18</sup> Urinary Neutrophil Gelatinase-Associated Lipocalin (NGAL) is a novel biomarker for detecting acute renal disorder.<sup>19</sup> Some studies state that NGAL could detect renal destruction early than creatinine serum.<sup>19,20</sup>

NGAL is a low molecule glycoprotein which is produced by human tissue like neutrophil, gaster, lung, colon, trachea, and kidney.<sup>21</sup> NGAL level will increase when there is an injury occurred in glomerular and kidney's tubule. NGAL is filtrated in glomerular, and some of them will be reabsorbed in proximal tubule. Normally, NGAL level is very low. An injury occurs in kidney's tubule will stimulate inflammation process and increased the permeability of its wall. NGAL which is filtrated in glomerular should be reabsorbed in proximal tubule, but because of the injury, this process will be disrupted, and results in high NGAL level in urine.<sup>22-24</sup>

The principle management of BPH with acute urinary retention is bladder decompression by introducing urinary catheter.<sup>25,26</sup> After urinary catheter insertion, a trial without of catheter (TWOC) could be considered a few weeks later.<sup>25</sup>

Renal function improvement after obstruction release could be divided into two phase; tubular phase (0-2 weeks); glomerular phase (2 weeks-3 months). Some of the improvements will be coming after two weeks and continue till the 3<sup>rd</sup> week.<sup>14</sup>

## OBJECTIVE

This study is done to evaluate renal function in BPH with acute urinary retention in acute condition and two weeks after urinary catheter insertion. In this study, renal function of each patient is evaluated using creatinine level and urinary NGAL parameter.

## MATERIAL & METHOD

This was an observational study co-hort. The samples were all patients with BPH and acute urinary retention who came to Soetomo General Hospital during research period of time and eligible for inclusion criteria. This research is done from April until September 2015.

The inclusion criteria were men 50 years old or older with acute urinary retention (pain and urinary volume 400 ml or greater) due to BPH who agreed to attend this research. Patient will be excluded from this research if he got heavy infection, had history of urinary retention or urinary catheter insertion in the last one month, prostate surgery, liver and pulmonary disorder.

All samples who were eligible for the inclusion criteria underwent clinical and laboratory investigation including urinary NGAL, creatinine serum, PSA, complete blood test, urinalysis, urine culture, and clinical chemistry. Patients also will undergo radiological investigation such as abdominal plain photo, trans-abdominal and trans-rectal USG. Urinary NGAL, creatinine serum, urinalysis, urine culture, ureum, and complete blood test will be check serially, when acute retention and 2 weeks after urinary catheter insertion. The kidney also will be evaluated using USG 2 weeks after urinary catheter insertion.

All the laboratory materials will be processed in the Clinical Pathology Laboratory Soetomo General Hospital. All the urine samples, will be centrifuged with 3000 rpm for 15 minutes before it will be stored in refrigerator (-80°C). Urinary NGAL is checked using NGAL kit DCLN20 type from R & D Inc. and read by ELISA using 450 nm wave length.

The results will be displayed in distribution table. The correlation between creatinine level and urinary NGAL when retention period with duration and urine volume of retention will be analysed using Program SPSS 22. T-test between creatinine and urinary NGAL when acute retention and 2 weeks after urinary catheter also will be analysed using the same program.

**RESULTS**

There were 31 samples who fulfilled the inclusion criteria. From the demographic analysis, the youngest age was 53 years old, the oldest age was 88 years old with mean  $67.4 \pm 7.2$ . Table 1 showed the mean duration of acute urinary retention was  $567.7 \pm 498$  minutes (9.5 hours) with mean pain score was  $5 \pm 1.59$ . Mean urinary retention volume was  $737 \pm 286$  ml. Mean prostate volume  $48.2 \pm 13.8$  ml. Mean PSA level was  $5.6 \pm 1.7$  ng/dL.

Mean creatinine level when acute urinary retention period was  $1.6 \pm 0.9$  mg/dL, and decreased 2 weeks after urinary catheter insertion (mean  $1.46 \pm$

$0.89$  mg/dL). The mean ureum level when acute urinary retention period was  $17.7 \pm 9$  mg/dL and became  $16.1 \pm 8$  md/dL 2 weeks after urinary catheter insertion. The mean GFR of all the samples when acute urinary retention period was  $47.7 \pm 19.4$  ml/minute, and got better 2 weeks after urinary catheter insertion ( $51.4 \pm 20.1$  ml/minute).

Urinary NGAL level when acute urinary retention period was  $308.1 \pm 244.8$  ng/dL. This level decreased 2 weeks after urinary catheter insertion ( $158.5 \pm 123.3$  ngdL).

The mean difference creatinin was  $0.1 \pm 0.17$ . While GFR mean difference was  $3.7 \pm 10.1$ . Urinary NGAL difference was  $139.9 \pm 222.2$ .

Sixteen out of 31 samples (51.6%) had comorbid disease like hypertension, diabetes mellitus, and/or hypertension and diabetes mellitus. Twenty out of 31 samples (64.5%) had a positive urine culture, and increased to be 21 patients (67.7%) 2 weeks after urinary catheter insertion.

Table 2 shows results of kidney evaluation using USG whan acute urinary retention period. There were 7 patients (22.6%) who experienced

**Table 1.** Patient Characteristics.

	Minimum	Maximum	Mean	Standard Deviation
Age (year)	53	88	67.4	7.2
Duration of retention (minute)	120	2880	567.7	498
VAS	2	8	5	1.59164
Body Weight (kg)	45	90	61.8	9.2
Height (cm)	150	172	163.2	5
Prostate Volume (ml)	30	86.9	48.2	13.8
PSA (ng/dl)	0.8	8.7	5.6	1.7
GFR during retention (ml/minute)	8.6	101.4	47.7	19.4
GFR after two weeks (ml/minute)	8.6	99.3	51.4	20.1
Delta GFR (ml/minute)	-24.3	36.1	3.7	10.1
Urinary retention volume (ml)	500	2000	737	286
Urinary production (ml)	1500	2500	1887	234.9
Bun during retention (mg/dl)	6	44	17.7	9
Bun after two weeks (mg/dl)	8	42	16.1	8
Creatinine during retention (mg/dl)	0.8	5	1.6	0.9
Creatinine after two weeks (mg/dl)	0.7	5	1.46	0.89
Delta creatinine (mg/dl)	-0.3	0.5	0.1	0.177
Urinary NGAL during retention (ng/ml)	56	930	308.1	244.8
Urinary NGAL after two weeks (ng/ml)	11	620	158.5	123.3
Delta urinary NGAL (ng/dl)	-53	830	139.9	222.22

**Table 2.** Patient characteristics based on co-morbidity, urine culture, and ultrasonography result.

	Positive (%)	Negative (%)	Total
Co-morbidity	16 (51.6)	15 (48.4)	31 (100)
Urine culture			
During retention	20 (64.5)	11 (35.5)	31 (100)
After two weeks	21 (67.7)	10 (32.3)	31 (100)
Hydronephrosis			
During retention	7 (22.6)	24 (77.4)	31 (100)
After two weeks	6 *(19.4)	25 (80.6)	31 (100)

\*hydronephrosis decrease

**Table 3.** Creatinine and urinary NGAL differences.

Variable	During retention	After 2 weeks Evaluation	Delta	P value
Creatinine	1.56 ± 0.9	1.46 ± 0.89	-0.1 ± 0.17	0.006
Urinary NGAL	308.1 ± 244.8	158.5 ± 123.3	-139.9 ± 222.2	<0.0001

**Table 4.** Creatinine and urinary NGAL correlation with duration of retention and urinary retention volume.

During retention	Duration of retention		Urinary retention volume	
	p	r	p	r
Creatinine	0.514	-0.122	0.841	-0.038
Urinary NGAL	0.367	-0.168	0.97	-0.303

Spearman's rho test, p < 0.05

hydronephrosis and the remaining patients (77.4%) were without hydronephrosis. After 2 weeks of urinary catheter insertion, 1 patient became normal (no hydronephrosis), while the others still had hydronephrosis, but with a slight improvement.

There was a significant difference in creatinine serum level in patients with BPH and acute urinary retention in acute phase and 2 weeks after urinary catheter insertion, with p value = 0.006 (table 3).

Urinary NGAL level in patients with BPH and acute urinary retention in acute phase decreased significantly after 2 weeks after urinary catheter insertion (p value < 0.0001).

The correlation between creatinine serum level and urinary NGAL when acute urinary retention period with the retention duration and urinary retention volume was analyzed using Spearman's correlation test. Creatinine level and urinary NGAL when acute urinary retention period does not have a significant correlation with duration of retention and urinary volume retention 9 (table 4).

## DISCUSSION

The mean age of the 31 samples was 67.4 years old. This was similar to other literature stated that the older the age, the higher the possibility of experiencing acute urinary retention. Patients with 70 years old have 4-6 times to get that condition compared with them aged less than 40 years old.<sup>2,11</sup> Mustonen found that the mean age of patient with acute urinary retention was 69 years old.<sup>16</sup>

The mean duration of urinary retention was 568 minutes or 9.47 hours. That was a little bit different with other literatures. The mean duration of Mustonen's research was approximately 31 hours.<sup>16</sup> This could be caused by social, cultural, and geographical difference of each patient. The mean urine volume in this research was 737 ml. That was similar to other researches which stated that the range of urine volume in patients with acute urinary retention was 500-1000 ml.<sup>6</sup>

Mean creatinine level during retention 1.6 mg/dl and after two weeks evaluation decrease to

1.46 mg/dl. Creatinine serum decreasing cause of obstruction relieve by catheterization. There was significant different creatinine level during retention and two weeks after catheterized  $p = 0.006$ . Mustonen had same result but he conduct renal function follow up until 6 month.<sup>16</sup> Tubular recovery began at first two weeks after relieve obstruction. After two weeks glomerular recovery was began and continue until at least for three month.<sup>14</sup>

Mean GFR patient during retention 47.7 ml/minute and after two weeks 51.4 ml/minute. Acute urinary retention can cause obstruction and increase renal pressure. This condition made GFR decrease during retention. Soon after releasing obstruction GFR gradually improved. This GFR changes was significant with  $p = 0.049$ . Mustonen also found significant improvement clearance creatinine patient after one month and 6 month evaluation  $p < 0.05$ .<sup>16</sup>

NGAL expression in urine increase more than 100 times normally during injury.<sup>17</sup> Mean NGAL level during retention in this study 308 ng/dl and after two weeks mean NGAL level 158.5 ng/dl. NGAL urine during retention and two weeks after evaluation had significant differences  $p < 0.0001$ . It showed that urethral catheter for relieve obstruction can improved NGAL level.

Creatinine and NGAL urine not significant correlated with duration of retention and urinary retention volume. This result different from literature that mention prolong obstruction can cause severe tubular damage and influence their renal function.<sup>13</sup>

Level NGAL and creatinine increasing in few patients although had catheterized. It seem, they renal function decrease cause of different factors. This study had several limitations. First, this study used creatinine not inulin clearance or renogram as gold standard for renal function test compare with NGAL urine. Second, we had not analyzed confounding factor such as co-morbidity, drugs consumption, diet modification, and fluid intake, which it can influence renal function. Need further investigation considering those confounding factors, larger number of patients, serial marker evaluation and longer follow up for renal function.

## CONCLUSION

BPH patient who have acute urinary retention had significant decreasing of creatinine and urinary NGAL levels during acute urinary retention

and two weeks after catheterized. Level creatinine and NGAL urine during retention not significant correlate with prolong duration of retention and urinary retention volume.

## REFERENCES

1. Roehrborn CG. Benign Prostatic Hyperplasia: Etiology, Pathophysiology, Epidemiology, and Natural History. In: Kavoussi LR, Partin AW, Novick AC, Peter CA, Editors. *Campbell Walsh Urology*, 10<sup>th</sup> Ed. Philadelphia, USA: Elsevier Saunders. 2012; Chapter 91: 2570-610.
2. Jacobsen SJ, Jacobson DJ, Girman CJ, Robert RO, Rhodes T, Guess HA, et al. Natural History of Prostatism: Risk Factors for Acute Urinary Retention. *JUrol*. 1997; 158: 481-7.
3. Jacobsen SJ, Jacobson DJ, Girman CJ, Robert RO, Rhodes T, Guess HA, et al. Treatment for Benign Prostatic Hyperplasia Among Community Dwelling Men: The Olmsted County Study of Urinary Symptom and Health Status. *The Journal of Urology*. October 1999; 162; 1301-6.
4. Meigs JB, Barry MJ, Giovannucci E, Rimm EB, Stampfer MJ, Kawachi I. Incidence Rates and Risk Factors for Acute Urinary Retention: The Health Professionals Follow Up Study. *The Journal of Urology*. 1999; 162; 376-82.
5. Barry MJ, Fowler FJ, Bin L, Pitts JC, Harris CJ, Mulley AG. The Natural History of Patients with Prostatic Hyperplasia as Diagnosed by North American Urologist. *JUrol*. 1997; 157: 10-15.
6. McAninch JW. Symptom of Disorder of the Genitourinary Tract. In Tanagho Emil A, and McAnich JW. Editors. In: *Smith's General Urology*, 17<sup>th</sup> ed. New York: McGraw-Hill Companies Inc, USA. 2008; Chapter 3: 30-38.
7. Jones Adam. Urological Emergencies. In: Dawson C, and Whitfield HG. Eds. in *ABC of Urology*. 2<sup>nd</sup> Ed. Massachusetts: Blackwell publishing Inc. 2006; chapter 4: 14-17.
8. Abrams P, Cardozo L, Fall M, Griffiths D, Rosier P, Ulmsten U, et al. Standardization Sub-committee of the International Continence Society. The standardization of terminology of lower urinary tract function: report from the Standardization Subcommittee of the International Continence Society. *Neurourol Urodyn*. 2002; 21: 167-78.
9. Abrams PH, Dunn M, George N. Urodynamic findings in chronic retention of urine and their relevance to results of surgery. *Br Med J*. 1978; 2: 1258-60.
10. Kalejaiye O, Speakman MJ. Management of Acute and Chronic Retention in Men. *European Urology Supplement*. 2008; 8; 523-9.
11. Kaplan SA, Wein AJ, Staskin DR, Roehrborn CG,

- Steers WD. Urinary Retention and Post-Void Residual Urine in Men: Separating Truth from Tradition. *The Journal of Urology*. July 2008; 180: 47-54.
12. Speakman MJ, Cheng Xi. Management of The Complication of BPH/BOO. *Indian Journal of Urology*. 2014; 30(2); 208-13.
  13. Ucero AC, Goncalves S, Benito-Martin A, Benito-Martin A, Santamaria B, Ramos AM, et al. Obstructive Renal Injury: from Fluid Mechanics to Molecular Cell Biology. *Open Access Journal of Urology*. 2010; 2; 41-55.
  14. Walker Roger. Renal Tract Obstruction and Acute Renal Failure. In: Glyne Paul, Allen Andrew, and Pusey Charles. Editors. In: *Acute Renal Failure in Practice*. London: Imperial College Press. 2002; chapter 23: 437-52.
  15. Vuuren VSPJ, Heyns CF, Zarrabi AD. Comparison of Men with Acute Versus Chronic Urinary Retention: Aetiology, Clinical Features and Complications. *S Afr Fam Pract*. 2011; 53(6); 590-4.
  16. Mustonen Sirkku. Effect of Acute Urinary Retention on Renal Function, Clinical Study in Men. Academic Dissertation. University of Tampere, Finland; 2001. p. 1-77. Available from URL: <http://www.tampub.uta.fi/bitstream/handle/124/67097/9514450671.pdf>, access time October 10, 2014.
  17. Munikrishnapa Devraj. Limitations of various Formulae and Other Ways of Assessing GFR in the Elderly: Is There a Role for Cystatin C? *Geriatric Nephrology Curriculum*. American Society of nephrology, 2009. Available from URL: [http://www.asn-online.org/education/distance\\_learning/curricula/geriatrics/chapter6.pdf](http://www.asn-online.org/education/distance_learning/curricula/geriatrics/chapter6.pdf), access time November 27, 2014.
  18. Perrone RD, Madias NE, Levey AS. Serum Creatinine as an Index of Renal Function: New Insights into Old Concepts. *Clinical Chemistry*. 1992; 38(10): 1933-53.
  19. McCullough PA, Shaw AD, Hasee Michael, Bouchard J, Waikar SS, Siew ED, et al. Diagnosis of Acute Kidney Injury Using Functional and Injury Biomarkers: Workgroup Statements from The Tenth Acute Dialysis Quality Initiative Consensus Conference. In: McCullough PA, Kellum JA, Mehta RL, Murray PT, and Ronco Claudio, Editors. *ADQI Consensus on AKI Biomarkers and Cardiorenal Syndrome*. Basel Switzerland: Karger; 2013. p. 13-29.
  20. McCullough PA, Bouchard Josee, Waikar SS, Siew ED, Endre ZH, Goldstein SL, et al. Implementation of Novel Biomarkers in the Diagnosis, Prognosis, and Management of Acute Kidney Injury: Executive Summary from The Tenth Consensus Conference of Acute Dialysis Quality Initiative (ADQI). In: McCullough PA, Kellum JA, Mehta RL, Murray PT, and Ronco Claudio, Editors. *ADQI Consensus on AKI Biomarkers and Cardiorenal Syndrome*. Basel Switzerland: Karger; 2013. p. 5-12.
  21. Chakraborty S, Kaur S, Tong Zhimin, Batra SK, Guha S. Neutrophil Gelatinase Associated Lipocalin: Structure, Function, and Role in Human pathogenesis. In: Veas, Francisco. Editor. in: *Acute Phase Protein - Regulation and Functions of Acute Phase Proteins*. Croatia: InTech; 2011. ISBN: 978-953-307-252-4, DOI: 10.5772/18755. Chapter 16, p. 345-72. Available from URL: <http://www.intechopen.com/books/acute-phase-proteins-regulation-and-functions-of-acute-phase-proteins/neutrophil-gelatinase-associated-lipocalin-structure-function-and-role-in-human-pathogenesis>, access time November 12, 2014.
  22. Kepka A, Wazkiewicz N, Chojnowska S, Szajda BZ, Ladny JR, Wasilewska A, et al. Utility of urinary Biomarkers in Kidney Transplant Fuction Assessment. *Intech*. Croatia. 2013. Chapter 3, p. 61-77. Available from URL: <http://www.intechopen.com/download/pdf/42864>, access time November 11, 2014.
  23. Tsigou Evdoxia, Psallida Vasiliki, Demponeras Christos, Boutzouka Eleni, Baltopoulos George. Role of New Biomarkers: Functional and Structural Damage. *Critical Care Research and Practice*; 2013. p. 1-13.
  24. Schmidt-Ott KM. Neutrophil Gelatinase-Associated Lipocalin as a Biomarker of Acute Kidney Injury-Where Do We Stand Today? *Nephrol Dial Transplant*. 2011; 0: 1-3.
  25. Fitzpatrick JM, Desgrandchamps F, Adjali K, Guerra GL, Hong SJ, Khalid SE, et al. Management of Acute Urinary Retention: a Worldwide Survey of 6074 Men with Benign Prostatic Hyperplasia. *BJU International*. 2011; 109: 88-95.
  26. Amritage James. 2011. The epidemiology and management of acute urinary retention: A study based on Hospital Episode Statistics and systematic literature review Thesis for the degree of Doctor of Medicine (Research) University College London; 2011. p. 1-150. Available from URL: <http://www.discovery.ucl.ac.uk/1318057/1318057.pdf>, access time October 20, 2014.