Effect of Thoracic Epidural Ropivacaine versus   
Bupivacaine on Lower Urinary Tract Function

A Randomized Clinical Trial

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ABSTRACT

Background: Thoracic epidural analgesia with bupivacaine resulted in clinically relevant postvoid residuals due to detrusor   
underactivity. This study aimed to compare the risk of bladder dysfunction with ropivacaine versus bupivacaine using postvoid   
residuals and maximum flow rates. Our hypothesis was that ropivacaine would result in lower postvoid residuals, because   
ropivacaine has been shown to have less effect on motor blockade.  
Methods: In this single-center, parallel-group, randomized, double-blind superiority trial, 42 patients undergoing open   
renal surgery were equally allocated to receive epidural bupivacaine 0.125% or ropivacaine 0.2%, and 36 were finally   
included. Inclusion criterion was normal bladder function. Patients underwent urodynamic investigations preoperatively   
and during thoracic epidural analgesia. Primary outcome was the difference in postvoid residual preoperatively and during   
thoracic epidural analgesia postoperatively. Secondary outcomes were changes in maximum flow rate between and within   
the groups.  
Results: Median difference in postvoid residual (ml) from baseline to postoperatively was 300 (range, 30 to 510; P < 0.001)   
for bupivacaine and 125 (range, −30 to 350; P = 0.011) for ropivacaine, with a significant mean difference between groups   
(−175; 95% CI, −295 to −40; P = 0.012). Median difference in maximum flow rate (ml/s) was more pronounced with bupi-  
vacaine (−12; range, −28 to 3; P < 0.001) than with ropivacaine (−4; range, −16 to 7; P = 0.025) with a significant mean dif-  
ference between groups (7; 95% CI, 0 to 12; P = 0.028). Pain scores were similar. No adverse events occurred.  
Conclusions: Postvoid residuals were significantly lower using ropivacaine compared to bupivacaine for thoracic epidural   
analgesia reflecting less impairment of detrusor function with ropivacaine. (Anesthesiology 2018; 128:511-9)

POSTOPERATIVE urinary retention is common with a

reported incidence of 5 to 70%.1 It is linked to several   
factors including type of surgery, preexisting neurologic dis-  
ease, increased age, increased intravenous fluid administra-  
tion, postoperative pain, and use of opioids and neuraxial   
anesthesia.1 The treatment of choice is bladder catheteriza-  
tion, which is associated with relevant morbidity (patient   
discomfort, urethral trauma, urethral stricture, and urinary   
tract infections). The risk of urinary tract infection with a   
single catheterization is 1 to 2% and can rise by 5 to 10%   
for every additional day with an indwelling catheter.2 It   
is the most common nosocomial infection in the United   
States, accounting for more than 1 million cases each year   
and 900,000 additional hospital days/yr. Urinary tract infec-  
tions are directly responsible for 13% of deaths related to   
nosocomial infections3 and are associated with high financial   
implications.4

Thoracic epidural analgesia (TEA) has been shown to   
provide the most effective analgesia as well as to facilitate   
postoperative rehabilitation after major thoracic or abdomi-  
nal surgery.5 TEA with bupivacaine alone or in combination   
with fentanyl or with fentanyl and epinephrine significantly   
inhibits detrusor function, which in turn results in clinically

What We Already Know about This Topic

• Epidural analgesia can provoke bladder dysfunction  
• Whether there is less urinary retention with ropivacaine than

bupivacaine remains unknown

What This Article Tells Us That Is New

• Postvoid bladder volume was less with ropivacaine than

bupivacaine, and urine flow was better maintained

• Ropivacaine is preferable to bupivacaine for bladder function

and may prevent catheterization in some patients

relevant postvoid residual urine volume (PVR), which   
requires monitoring or catheterization.6–8 Ropivacaine, on   
the other hand, administered in the lumbar epidural space   
during labor, affects motor blockade of the lower extremities   
to a clinically relevant lesser degree than bupivacaine. Thus,   
the two local anesthetics may have different effects on blad-  
der function.9 However, the analgesic potency of ropivacaine   
is approximately 60% of that of bupivacaine.10

The objective of this study was to investigate the effect of   
ropivacaine in the thoracic epidural space on bladder func-  
tion and compare it to the effect of equianalgesic doses of   
bupivacaine. The hypothesis being that ropivacaine would

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have less impact on bladder function, assessed by PVR and   
urodynamic investigations.

Materials and Methods

Ethics  
This single-center, randomized, double-blind, parallel-group   
interventional superiority study was approved by the local   
ethics committee of the University Hospital of Bern (KEK   
Bern, Switzerland, KEKBE 390/14), prospectively registered   
at ClinicalTrials.gov (NCT02414373, principal investigator   
P. Y. Wuethrich, date of registration: March 26, 2015) and   
conducted in compliance with the Declaration of Helsinki   
and good clinical practice. Full trial protocol can be accessed   
on request. All patients gave preoperative written informed   
consent to participate.

Study Design and Patients  
Patients planned for open renal surgery were screened for   
inclusion at the Department of Urology of the University   
Hospital of Bern, Bern, Switzerland. All recruited patients   
completed the validated International Prostate Symptom   
Score questionnaire.11 Only patients with no preexisting   
lower urinary tract symptoms (Internationale Prostate Symp-  
tom Score less than or equal to 7) and a PVR less than 100 ml   
(assessed by ultrasound) were included after providing writ-  
ten informed consent.12 Exclusion criteria were any contrain-  
dication to TEA and pregnancy (exclusion for surgery per se).  
Forty-two patients were equally randomly allocated to   
either TEA with bupivacaine 0.125% or ropivacaine 0.2%   
by a computer-generated randomization list without block-  
ing, following the recommendation of the Consolidated   
Standards of Reporting Trials statements. The allocation   
sequence was prepared by an independent operator not   
involved in the study, and the allocation assignment was   
concealed in opaque sealed envelopes that were sequentially   
numbered. Patients were allocated to the treatment group by   
assigning them the sequentially numbered envelope with the   
lowest number. Patients and investigators of bladder func-  
tion were blinded to the epidural solution administrated; the   
contents of the epidural mixture were not distinguishable   
because the vials were placed in a sealed opaque bag by an   
anesthesiologist not involved in the study before patient and   
investigator entered the urodynamic room.

Time Course and Intervention  
After recruitment, the first (baseline) urodynamic investi-  
gation was performed without TEA the day before surgery.   
Urodynamic investigations were performed according to good   
urodynamic practice.13 After placement of a 6 French trans-  
urethral dual channel catheter (B. Braun Medical, Germany)   
and a 14 French rectal balloon catheter (Gaeltec, United   
Kingdom), the bladder was filled at a rate of 25 to 50 ml/  
min with Ringer’s lactate solution at room temperature. The   
rectal catheter measures rectal, i.e., intraabdominal, pressure.

Bladder Function: Ropivacaine or Bupivacaine?

Detrusor pressure is calculated by subtracting the intraab-  
dominal pressure from the intravesical pressure resulting   
(e.g., during coughing) in the pressure increase produced by   
the detrusor muscle itself (detrusor pressure).13 Parameters of   
both the storage phase (bladder volume at first desire to void,   
bladder volume at strong desire to void, maximum cystomet-  
ric capacity (maximum filling volume), bladder compliance   
(relationship between change in bladder volume and change   
in detrusor pressure), and voiding phase (maximum detrusor   
pressure, detrusor pressure at maximum flow rate, maximum   
flow rate, and PVR were recorded (fig. 1). An Aquarius XT   
multichannel urodynamic system was used for all measure-  
ments (Laborie Medical Technologies Corp., Canada). The   
methods, definitions, and units accord with the standards rec-  
ommended by the International Continence Society.14

All patients received a thoracic epidural catheter placed at   
the interspace T7–8 or T8–9 before induction of anesthesia.   
The insertion site was determined using the classic landmark   
method, whereby the spinal process of T7 was identified at the   
line intersecting the inferior tip of the scapulae in the sitting   
position. An 18-gauge epidural needle was inserted by a para-  
median or median approach, and the epidural space was identi-  
fied with the loss-of-resistance technique. A test dose of 1.5 ml   
of lidocaine 20 mg/ml with 0.005 mg/ml epinephrine was   
given to rule out subarachnoidal or intravascular placement.

TEA was then activated 20 min before skin incision with   
bupivacaine 2.5 mg/ml at a rate of 6 to 10 ml/h in both   
groups during surgery. No opioids were administrated epi-  
durally during surgery. General anesthesia was induced with   
propofol, fentanyl, and rocuronium and maintained with   
isoflurane. A transurethral catheter was inserted after induc-  
tion and left in place until the next urodynamic investiga-  
tion. At the end of surgery, continuous epidural analgesia   
was maintained with the epidural drug according to the ran-  
domization: bupivacaine 1.25 mg/ml (bupivacaine group)   
(bupivacain 0.125% Bioren; Sintetica–Bioren, Switzerland)   
or ropivacaine 2 mg/ml (ropivacaine group; naropin 0.2%   
Sintetica; Sintetica–Bioren) using a CADD Legacy ambu-  
latory infusion pump (model 6300; Deltec Inc., USA).   
The initial infusion rate was 8 ml/h, with additional bolus   
volumes of 5 ml (lockout time: 1 h). Higher concentrated   
ropivacaine was used to reach equipotent analgesia because   
analgesic potency of ropivacaine is approximately 60% of   
that of bupivacaine.10

The infusion rate was then adapted if necessary based   
on assessments made every 4 h to maintain a pain intensity   
lower than 3 at rest and lower than 5 during mobilization on   
the numeric rating scale (NRS), in which 0 = no pain and   
10 = worst pain imaginable. The maximum infusion rate was   
15 ml/h. Additional rescue analgesia with a systemic administra-  
tion of opioids (fentanyl) was permitted if the NRS was defined   
as a NRS of more than 5 after optimization of the TEA.

The level of sensory blockade was assessed by hyposensitivity   
to cold. A cold gel bag (Nexcare reusable cold pack; 3M, USA)   
with a surface of 4 cm2 was applied for 1 s to each dermatome.15

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Fig. 1. (A) Example of a representative urodynamic tracing from a study patient showing one micturition at baseline. An electromy-  
ography (EMG) shows tracing taken from the pelvic floor muscles by perianal surface electrodes. (B) A representative urodynamic   
tracing from a study patient showing one micturition cycle during thoracic epidural analgesia postoperatively with urinary reten-  
tion due to detrusor muscle underactivity. Flow = voided urine measured on the scale over time; Pabd = intraabdominal pressure   
(measured by the rectal balloon); Pdet = detrusor pressure (calculated as difference from Pves – Pabd); PdetQmax = detrusor   
pressure at maximum flow rate; Pves = intravesical pressure; Qmax = maximum flow rate; Vinf = filling of the bladder.

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The second urodynamic investigation was performed on   
the second or third postoperative day around noon, depend-  
ing on the patient’s mobilization. Patients were mobilized   
the evening after surgery (bedside mobilization) and then   
were encouraged to ambulate on postoperative day 1 (short   
walk on the ward). Segmental blockade was assessed at 8:00   
AM, and if necessary, the epidural mixture rate was optimized   
to achieve a segmental blockade above T6 and below T10,   
not exceeding T12 bilaterally. Potential risk factors for post-  
operative urinary retention (postoperative rescue opioid   
requirement, postoperative nausea and vomiting, sedation)   
were also documented.

Endpoints  
The primary endpoint was within-patient difference (Δ) in   
PVR (Δ = value during TEA postoperatively – baseline value)   
between the two groups. Secondary endpoints were within-  
patient difference in bladder volume at first desire to void,   
bladder volume at strong desire to void, maximum cystomet-  
ric capacity, bladder compliance, maximum detrusor pres-  
sure, detrusor pressure at maximum flow rate, maximum flow   
rate, PVR between the time points (during TEA postopera-  
tively vs. baseline), and postoperative pain scores according to   
the NRS. The bladder contractility index, which reflects the   
strength of the detrusor contraction, was calculated accord-  
ing to the formula “detrusor pressure at maximum flow rate   
plus 5 maximum flow rate.” Bladder voiding efficiency, the   
product of bladder contractility against urethral resistance,   
was defined as the percentage of voided volume/maximum   
cystometric capacity.16,17 Side effects potentially related to   
ropivacaine and bupivacaine were also recorded.

Statistical Analysis  
This randomized superiority study was designed to have   
90% power to detect a between-group difference in within-  
patient PVR difference (Δ) of 180 ml during TEA post-  
operatively versus before TEA using a two-sided t test at a   
significance level of 5%, assuming a SD of 210 ml.6,7 Such a   
difference is considered clinically relevant.18 This resulted in   
a sample size of 17 patients/group. Assuming a drop out of   
around 20%, 42 patients (i.e., 21 patients in the bupivacaine   
group and 21 in the ropivacaine group) were enrolled.

Statistical analyses were conducted on a modified inten-  
tion-to-treat basis because patients who did not have the sec-  
ond urodynamic investigation had to be excluded from the   
analysis. The data are expressed in medians with ranges for   
continuous variables or frequencies for categorical ones. For   
quantitative endpoints, the two groups were compared using   
the Wilcoxon rank-sum test, accompanied with point estimate   
and 95% CIs for Hodges–Lehmann estimator for differences   
of the two group medians for each of the pairwise compari-  
sons. Within each group, the within-patient prepostoperative   
differences were analyzed using the Wilcoxon signed-rank test.   
Categorical endpoints were analyzed using the Fisher’s exact   
test. A two-sided P value of less than 0.05 was considered

Bladder Function: Ropivacaine or Bupivacaine?

statistically significant. The statistical software used was IBM   
SPSS Statistics 24.0 (SPSS Inc., USA).

Results

Between April 2015 and May 2017, a total of 62 patients   
were assessed for eligibility, and 42 patients underwent ran-  
domization. Two patients in the bupivacaine group (TEA   
with insufficient segmental blockade (n = 1) and refusal   
to undergo the second urodynamic investigation during   
TEA (n = 1) and 4 patients in the ropivacaine group (TEA   
with insufficient segmental blockade (n = 1) and refusal to   
undergo the second urodynamic investigation during TEA   
(n = 3) dropped out (fig.  2). Baseline characteristics and   
pain scores were similar between the two groups (table 1).   
The upper and lower segmental level of analgesia did not   
differ significantly between the groups. No systemic opioids   
and no sedatives were administrated postoperatively, and no   
postoperative nausea and vomiting were documented. No   
motor blockade related to TEA was present (Bromage motor   
block score of 0 in all patients). No adverse events related to   
the drugs administered occurred.

Voiding Phase  
Within-patients differences in voiding phase parameters   
were all statistically significant (table  2). Median ΔPVR   
from baseline to postoperatively was 300 ml (range, 30 to   
510; P < 0.001) in the bupivacaine group and 125 ml (range,   
−30 to 350; P = 0.011) in the ropivacaine group; with a sig-  
nificant difference between the groups (Hodges–Lehmann   
median difference, −175; 95% CI, −295 to −40; P = 0.012;   
fig. 3). Median Δ voided volume was −320 ml (range, −800   
to −50; P < 0.001) in the bupivacaine group and −70 ml   
(range, −600 to 0; P = 0.005) in the ropivacaine group, with   
a significant difference between the groups (Hodges–Lehm-  
ann median difference, 250; 95% CI, 50 to 375; P = 0.003).   
Median Δ maximum flow rate was significantly more pro-  
nounced in the bupivacaine group (−12 ml/s; range, −28 to   
3; P < 0.001) than in the ropivacaine group (−4 ml/s; range,   
−16 to 7; P  =  0.025), and this difference was significant   
between the groups (Hodges–Lehmann median difference,   
7; 95% CI, 0 to 12; P = 0.028). Four patients (2 women and   
2 men) in the bupivacaine group (21%) and 2 patients (2   
men) in the ropivacaine group (12%) had a maximum flow   
rate of 0 ml/s during TEA postoperatively and were totally   
unable to void (P = 0.664).

The bladder contractility index was significantly reduced   
in both groups: bupivacaine group (−59; range, −140 to 17;   
P < 0.001) ropivacaine group (−28; range, −114 to 26; P = 0.002),   
and this difference was significant between the groups (Hodges–  
Lehmann median difference, 31; 95% CI, 4 to 59; P = 0.022).   
Bladder voiding efficiency was significantly reduced in the bupi-  
vacaine group (−53%; range, −100 to 3; P < 0.001) but not in   
the ropivacaine group (−10%; range, −100 to 9; P = 0.124); this   
difference was significant between the groups (Hodges–Lehmann   
median difference 42; 95% CI, 4 to 71; P = 0.016).

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Day 2 or 3 Postoperative (n=17)

Day 2 or 3 Postoperative (n=19)

Fig. 2. Consolidated Standards of Reporting Trials flow diagram indicating the urodynamic protocols in the study groups.   
NRS = numerical rating scale.

Table 1. Baseline Characteristics

Sex (women/men)  
ASA classification (II/III)  
Age (yr)  
IPSS  
IPSS QoL (1/2/3)  
Epidural mixture rate postoperatively (ml/h)  
NRS at rest  
NRS during mobilization  
Segmental blockade

Upper thoracic dermatome  
 Lower thoracic dermatome

Bupivacaine  
Group (n = 19)

Ropivacaine  
Group (n = 17)

Estimate of Group   
 Difference

6/13  
10/9  
59 (43, 77)  
2 (0, 7)  
10/9/0  
8 (4, 12)  
0 (0, 3)  
2 (1, 5)  
   
4 (3, 6)  
12 (11, 12)

8/9  
8/9  
55 (27, 70)  
3 (1, 6)  
7/7/3  
8 (4, 12)  
0 (0, 3)  
2 (1, 5)  
   
4 (4, 6)  
12 (10, 12)

P Value

0.342  
0.739  
0.999  
0.235  
0.159  
0.334  
0.650  
0.524

0.986  
0.899

95% CI

−14 to 3  
0 to 2  
   
−2 to 1  
0 to 0  
−1 to 0  
   
0 to 0  
0 to 0

−4  
1  
   
−1  
0  
0  
   
0  
0

The data are presented as count or median value (range).  
ASA = American Society of Anesthesiologists; IPSS = international prostate symptom score; NRS = numeric rating scale for pain, in which 0 = no pain and   
10 = worst pain imaginable; QoL = quality of life.

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Bladder Function: Ropivacaine or Bupivacaine?

Table 2. Within-patient Absolute Values and Difference (Value during TEA – Baseline Value) and Between-group Estimate of   
Difference (Ropivacaine Group vs. Bupivacaine Group) of the Parameters of the Voiding Phase

Bupivacaine  
Group (n = 19)

Ropivacaine  
Group (n = 17)

Estimates (95% CI)

P Value\*

Median (Range)

Ropivacaine vs. Bupivacaine Group

Baseline  
 During TEA  
 Within-patient difference  
 P value†

Baseline  
 During TEA  
 Within-patient difference  
 P value†

Baseline  
 During TEA  
 Within-patient difference  
 P value†

Postvoid residual (ml)  
   
   
   
   
Voided volume (ml)  
   
   
   
   
Maximum detrusor pressure (cm H2O)  
   
   
   
   
Detrusor pressure at maximum flow rate (cm H2O)  
   
   
   
   
Maximum flow rate (ml/s)  
   
   
   
   
Bladder contractility index  
   
   
   
P value†  
Bladder voiding efficiency (%)

Baseline  
 During TEA  
 Within-patient difference  
 P value†

Baseline  
 During TEA  
 Within-patient difference  
 P value†

Baseline  
 During TEA  
 Within-patient difference  
 P value†

Baseline  
 During TEA  
 Within-patient difference

10 (0 to 70)  
325 (50 to 700)  
300 (30 to 510)  
< 0.001  
   
520 (150 to 960)  
125 (0 to 745)  
−320 (−800 to -50)  
< 0.001  
   
33 (1 to 80)  
23 (0 to 80)  
−7 (−35 to 50)  
0.017

28 (8 to 60)  
15 (0 to 62)  
−12 (−31 to 7)

0.001

18 (11 to 42)  
6 (0 to 27)  
−12 (−28 to 3)  
< 0.001  
   
125 (91 to 228)  
48 (0 to 150)  
−59 (−140 to 17)  
 < 0.001  
   
97 (65 to 174)  
27 (0 to 100)  
−53 (−100 to 3)  
< 0.001

25 (0 to 95)  
125 (0 to 350)  
125 (−30 to 350)

0.011

350 (210 to 600)  
300 (0 to 535)  
−70 (−600 to 0)

0.005

35 (10 to 75)  
29 (0 to 74)  
−3 (−52 to 1)

0.003

34 (8 to 61)  
25 (0 to 60)  
−5 (−46 to 8)

0.013

16 (9 to 20)  
11 (0 to 27)  
−4 (−16 to 7)

0.025

114 (87 to 132)  
80 (0 to 154)  
−28 (−114 to 26)

0.002  
   
95 (60 to100)  
85 (0 to 103)  
−10 (−100 to 9)

0.124

−175 (−295 to −40)  
   
   
   
   
250 (50 to 375)  
   
   
   
   
4 (−8 to 12)  
   
   
   
   
7 (−5 to 19)

7 (0 to 12)  
   
   
   
   
31 (4 to 59)

42 (4 to 71)

0.012  
   
   
   
   
0.003  
   
   
   
   
0.842  
   
   
   
   
0.250  
   
   
   
   
0.028  
   
   
   
   
0.022

0.016

\*Within-group P value derived from the Wilcoxon signed rank test for within-patient value during TEA – baseline value difference of each endpoint. †Between-  
group P value from Wilcoxon rank sum test for within-patient value during TEA – baseline value difference. Point estimates for Hodges–Lehmann median   
difference with 95% CI were constructed accordingly. Two-sided P value < 0.05 as statistically significant.  
TEA = thoracic epidural analgesia.

Storage Phase  
Between-group differences in storage phase parameters did   
not differ significantly (table  3). Within-patient median Δ   
bladder compliance was −46 ml/cm H2O (range, −473 to 45;   
P < 0.001) in the bupivacaine group. No adverse events (urinary   
tract infections, pain in the urinary tract requiring analgesic   
treatment) related to the urodynamic investigations occurred.

Discussion

TEA with ropivacaine has a less pronounced effect on void-  
ing function than with bupivacaine. Although segmen-  
tal blockade from around T4 to T12 with both drugs was   
associated with a relevant impairment in voiding function,

patients in the bupivacaine group developed clinically rel-  
evant PVRs. The median ΔPVR of at least 200 ml during   
TEA in the bupivacaine group represents a clinically relevant   
impairment in voiding function, which is associated with an   
increased risk of complications (urinary tract infection).19   
In addition, 21% of the patients in the bupivacaine group   
and 12% in the ropivacaine group were completely unable   
to void (i.e., urine flow rate of 0), even though we could not   
detect a statistical significance; this finding is clinically rel-  
evant because these patients need catheterization.

Our results confirm our previous observation that segmental   
blockade with epidurally administered local anesthetics results   
in detrusor underactivity and a decreased flow rate.8 However,

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the administration of ropivacaine resulted in less dramatic   
reduction of urinary flow rate, explaining the lower ΔPVR and   
higher voided volume differences compared to bupivacaine.   
The differences in bladder contractility index reflecting the   
strength of detrusor contraction and bladder voiding efficiency   
were larger in the bupivacaine group, reflecting the greater   
impact on the detrusor muscle also significantly reduced in the   
bupivacaine group compared to the ropivacaine group.

Bupivacaine and ropivacaine have nearly identical chemi-  
cal structure; the only difference is a propyl group and a

butyl group attached to the pipechol ring for ropivacaine   
and bupivacaine, respectively, making ropivacaine a smaller   
molecule than bupivacaine.10 The analgesic potency of ropi-  
vacaine is around 60% of that of bupivacaine. For this rea-  
son, to achieve an equipotent effect, bupivacaine 0.125% was   
compared with ropivacaine 0.2%, and we did find similar   
pain scores at rest and during mobilization in the two groups.   
Ropivacaine, however, produced a greater dissociation of sen-  
sory to motor block than bupivacaine. This is in line with   
the fact that in terms of motor block, ropivacaine is 66% less   
potent than bupivacaine.20,21 In addition, there is a minimal   
advantage in terms of toxicity in favor of ropivacaine. The   
reduced effect of ropivacaine on detrusor contractility could   
be explained by a decreased affinity for sodium channels in   
motor neurons. Different affinities for various subtypes of   
sodium channels have been demonstrated in other studies,   
e.g., the subtype Na(v)1.8.22 It is unclear, however, how this   
applies to ropivacaine. In addition, ropivacaine is less lipo-  
philic than bupivacaine. The decreased lipophilicity reduces   
the penetration of the larger myelinated nerve fibers (Aα, Aβ,   
and Aδ fibers) by ropivacaine due to the substitution of the   
pipecoloxylidine with a three-carbon side chain instead of a   
four-carbon side chain.23,24 In a similar way, the less lipophilic   
properties of ropivacaine could result in smaller amounts of   
local anesthetic penetrating the dura mater, which would   
further explain the decreased potency and smaller degree of

B u p iv a c a in e G r o u p R o p iv a c a in e G r o u p

Fig. 3. Differences in postvoid residual urine volume shown   
as median with interquartile ranges and with maximum and   
minimum values (P = 0.012).

Table 3. Within-patient Absolute Values and Difference (Value during TEA – Baseline Value) and Between-group Estimate of   
Difference (Ropivacaine Group vs. Bupivacaine Group) of the Parameters of the Storage Phase

Median (Range)

Ropivacaine vs. Bupivacaine Group

Bupivacaine  
Group (n = 19)

Ropivacaine  
Group (n = 17)

Estimate (95% CI)

P Value\*

Baseline  
 During TEA  
 Within-patient difference  
 P value†

Baseline  
 During TEA  
 Within-patient difference  
 P value†

Bladder volume at first desire to void (ml)  
   
   
   
   
Bladder volume at strong desire to void (ml)  
   
   
   
   
Maximum cystometric capacity (ml)  
   
   
   
   
Compliance (ml/cm H2O)

Baseline  
 During TEA  
 Within-patient difference  
 P value†

Baseline  
 During TEA  
 Within-patient difference  
 P value†

260 (30 to 470)  
220 (50 to 610)

−8 (−120 to 195)  
0.825

460 (140 to 815)  
385 (100 to 700)  
−50 (−315 to 160)  
0.021

545 (200 to 970)  
460 (140 to 745)  
−14 (−420 to 245)  
0.287

89 (17 to 500)  
36 (13 to 240)  
−46 (−473 to 45)  
< 0.001

180 (80 to 355)  
200 (60 to 400)

5 (−100 to 320)

0.649

305 (160 to 625)  
310 (85 to 500)  
−5 (−165 to140)  
0.415

420 (210 to 625)  
350 (140 to 540)  
−41 (−190 to 10)  
0.003

50 (19 to 100)  
35 (17 to 400)  
−10 (−100 to 25)  
0.109

13 (−61 to 55)  
   
   
   
   
45 (−25 to 123)  
   
   
   
   
−28 (−100 to 70)  
   
   
   
   
35 (−8 to 72)

0.730  
   
   
   
   
0.128  
   
   
   
   
0.413  
   
   
   
   
0.842

\*Between-group P value from Wilcoxon rank sum test for within-patient value during TEA – baseline value difference. Point estimates for Hodges–Lehmann   
median difference with 95% CI were constructed accordingly. Two-sided P value < 0.05 as statistically significant. †Within-group P value derived from the   
Wilcoxon signed rank test for within-patient value during TEA – baseline value difference of each endpoint.   
TEA = thoracic epidural analgesia.

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motor block.25 This remains speculative because these are in   
vitro observations and with higher concentrations than used   
in this study.26–28 The different physiochemical properties of   
the two local anesthetics may also play a role because ropiva-  
caine is an almost pure L-isomer, and bupivacaine is a race-  
mic mixture; the D-isomer of bupivacaine could alter receptor   
binding in larger nerve fibers.9

Another issue is the nature of the epidural space and the   
distribution of local anesthetics, demonstrated in a cadaver   
study using cryomicrotome sections. Hogan et al.29 found   
that the distribution of drugs injected in the epidural space   
follows paths between structures according to pressures by   
which they are compressed. This could explain the wide CIs   
and why some patients in both groups were able to void with   
unchanged voided volumes and PVRs while others had blad-  
der retention with detrusor undercontractility.

Bupivacaine also had a greater effect on bladder compli-  
ance than ropivacaine, however, without fulfilling the crite-  
ria of a low compliant bladder.30 This observation is similar   
to our precedent studies involving epidurally administered   
bupivacaine 0.125% with or without additional fentanyl.   
On the other hand, maximum cystometric capacity was sig-  
nificantly reduced in the ropivacaine group. This may explain   
the more effective voiding because the less-filled bladder may   
contract more effectively according to the law of Laplace.

Early catheter removal after surgery in an attempt to   
avoid or minimize the rate of urinary tract infections and   
urethral trauma has become a major focus of interest and   
is part of enhanced recovery programs.31–33 Despite the   
reduced effect of ropivacaine on bladder function, proper   
assessment and monitoring of PVRs during TEA is still   
recommended because some patients were unable to void.   
Because patients report a sensation of bladder filling even   
when the bladder is not filled, an objective quantification is   
mandatory even in case if sensory function should be con-  
sidered as intact.34

We are aware of certain limitations of our study: silent   
voiding dysfunction may be unmasked during TEA or after   
surgery, and our study was not placebo-controlled; however,   
placebo TEA for postoperative analgesia would give rise   
to ethical concerns. In this study, we considered a PVR of   
more than 200 ml clinically relevant in patients with normal   
preoperative voiding function; however, this value has been   
challenged. Brouwer et al.35 found that using an individual   
residual volume based on maximum cystometric capac-  
ity rather than a fixed volume could lead to a decrease in   
catheterization.

In conclusion, thoracic epidurally administrated bupi-  
vacaine 0.125% led to a more pronounced impairment   
of detrusor activity with a greater increase in PVRs than   
ropivacaine 0.2%. Based on our results, ropivacaine 0.2%   
is the preferred drug to achieve early catheter removal.   
However, because detrusor contractility is also affected with   
ropivacaine 0.2%, careful monitoring of PVRs remains   
recommended.

Bladder Function: Ropivacaine or Bupivacaine?

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Competing Interests  
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Reproducible Science  
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