5. Discussion

5.1 Development and conduction of survey

The questionnaire used in this study was developed like the list of Heikes[27] on Spivey's[63] method to determine curriculum content. This technique consists of analyzing and delineating potential performances from various sources and then presenting this to the appropriate group of respondents. For the present study this involved the compilation of a list of clinical procedures important for general practitioners in South Africa. The list was compiled by an extensive literature research study, personal experience and discussions with general practitioners and faculty. A list of 57 procedures was compiled and a questionnaire developed to assess various aspects of procedures performed including the role of the underlying anatomy.

Of the 102 questionnaires obtained, 5 were not fully completed and were therefore not included in the study. A total of 97 questionnaires were therefore analyzed. All the questionnaires were filled out by general practitioners in the various hospital practices. Hospitals in three provinces were selected and all the general practitioners present at a random date filled out the questionnaire voluntarily and anonymously. Although 3 provinces in South Africa were included in the study, the scenario for clinical procedures in other parts of South Africa may be somewhat different. This study may therefore have limited geographic generalizability. It is thought however, that the data presented reflect a general picture due to the representative number of general practitioners that took part in the study in Gauteng, Northern Province and Mpumalanga. A limitation of the study is the fact that the different hospitals were not randomly selected in the sense that each hospital had an equal chance to be selected. The aim was however to obtain two groups of hospital practices where at least 40 different respondees could be obtained.

This study embarked on an evidence-based medicine approach for procedural training for general practitioners. It may serve as a basis on which procedures should be taught in residency programs to prepare general practitioners for their future practice as well as for continued medical education courses. There is a need for assessing real, perceived and expressed educational needs in South Africa as pointed out by De Villiers[50]. This study addresses the educational needs of general practitioners regarding procedural competence. Similar studies have been conducted in Australia[64] and The Netherlands[65]. Data from these studies proved relevant to health care planning and education regarding the demand on doctors to perform clinical procedures.

Abrahams[66] performed a similar study in 1985, which did not focus specifically on the clinical anatomy of procedures, but a broad evaluation of the applications of anatomy in general practice. In his study, three levels of anatomical knowledge were considered which were 1) no anatomy needed during the consultation, 2) routine physical examination and 3) surface anatomy and detailed specific anatomical knowledge required for specific diagnosis and clinical reasoning. It was found that especially in the second group, anatomy was essential in 62.5% of 4131 consultations. The evidence base that this study revealed has great implications for clinical training of general practitioners. There

is however a need to extent this evidence base to unique circumstances in developing countries also with regard to procedural training of doctors.

The demographic characteristics reveal important information, which is necessary to have when developing any procedural training program. It is of great importance to know the target audience in order to focus on their specific characteristics and therefore not over- or underestimate their competence[31].

Concerning the age of general practitioners, the rural doctors group in hospital practice are notably younger than the urban doctors group with 55% of rural doctors in the age group 23-30 years compared to 39% of the urban doctors. Regarding sex, it was found that more doctors in rural hospitals are male (73%) compared to urban doctors (60%). This is similar to findings in Australia[64]. This may be explained by the fact that young doctors are more likely to work in rural hospital practices because of the opportunity to gain hands on experience and the possible absense of family commitments which are better met in urban areas.

Overall urban doctors seem more experienced regarding their years in hospital practice, although both groups consist of doctors with no more than 5 years in practice since graduation, 42% for the urban doctors and 62% for the rural doctors.
It is not surprising that urban doctors overall have more postgraduate training, due to both the fact that they are older and therefore have more years in practice and the fact that more opportunities exist in urban hospitals regarding postgraduate medical training. This also explains the higher competency levels found in the study. It is encouraging to note that nearly a third (30%) of the urban doctors have done or are busy with the postgraduate masters training in Family Medicine (MMedFam Med) and a fifth (21%) of the rural doctors.

5.1.1 Incidence of performance

Various bodies have compiled lists for what is regarded as core procedures in family practice. The National Health Services (NHS) in the UK has compiled such a list of procedures[37].

It is clear from our data that this list is very different from the procedures that general practitioners perform in South African hospital practices. General practitioners perform a wide range of procedures, which include procedures that are usually performed by specialists in developed countries. The number of the procedures varies with the nature of the practice situation, whether urban or rural, which confirms data presented by other studies [44,45,46,47].
Our study shows that general practitioners in hospital practices perform a wide variety of procedures, ranging from non-invasive procedures such as interpretation of radiographic images to invasive surgical procedures like cesarean sections and appendectomies.

Various other procedures were listed by the responding doctors for both urban and rural practices. They are listed in section 4.1.1 and were listed by individual doctors and were

not by any means noted by the majority of practitioners. These procedures should also be evaluated in future studies for most of them are not only invasive, but rely strongly on a sound anatomical understanding.

- **Emergency procedures**

Regarding emergency procedures, it is striking that almost all procedures evaluated are performed by more than 50% of the doctors. Exceptions are cricothyroidotomy (26.32%), pericardiocentesis (23.16%), pretibial intraosseous puncture/infusion (41.05%) and internal jugular vein catheterization (45.26%). These procedures either have alternatives which scored highly or have a lower incidence because they are less often needed.

Procedures with an extremely high incidence include oro/nasotracheal intubation (95.79%), intercostal drain insertion (90.53%), lumbar puncture (90.53%), eye injury examination (89.47%) and suprapubic puncture and catheterization (75.79%). It is clear that the demand for competency in emergency procedures is very high.

- **Surgical procedures**

Regarding surgical procedures, although less often performed when compared to emergency procedures, a substantial number are very often performed. They include dilatation and curettage (80.00%), normal vaginal delivery (78.95%), cesarean section (74.74%), episiotomies (73.68%), circumcision (72.63%), sterilization (70.53%) and reduction of uncomplicated forearm fractures (69.47%).

These are almost all highly invasive procedures, which are almost certainly performed by specialists like obstetricians and gynecologists, general surgeons or orthopedic surgeons in developed countries. The importance of sound surgical procedural training is underscored by these figures.

Procedures that are seldomly performed include pudendal nerve block (15.79%) and brachial plexus block (16.84%). Suprisingly sigmoidoscopy and proctoscopy are seldomly performed (29.47%). This may be due to the fact that the procedures were not separated in the questionnaire for there may be more doctors who perform a proctoscopy compared to a sigmoidoscopy.

- **Office procedures**

Concerning office procedures, rectal examination (97.89%) and vaginal examination (98.95%) are performed extremely often as would be expected.

Others like the management of epistaxis (95.79%), aspiration of pleural effusions (85.26%), reduction of shoulder dislocation (81.05%), knee joint aspiration (78.95%) are very often performed.

Surprisingly, injection of the shoulder joint (29.47%), indirect laryngoscopy (30.53%)

and nasopharyngoscopy (10.53%) are not often performed. These procedures are very effective and not invasive. There may be a lack of understanding of the value of these procedures.

Upper gastrointestinal endoscopy (9.47%), colposcopy (14.74%) and slit lamp examination (13.68%) are seldomly performed as was expected. Lack of specialized equipment may be one reason.

- **Imaging procedures**

Concerning imaging procedures, the following are performed extremely often as is expected: abdominal X-ray (93.68%), chest X-ray (92.63%), pelvic X-ray (92.63) and neck X-ray (91.58%).

Very surprisingly is the fact that an obstetric ultrasound is performed very often (82.11%) and an abdominal ultrasound by nearly two thirds of doctors (58.95%). Residency programs rarely offer training programs in these imaging procedures and training is often done by courses in a continued medical education environment.

Musculoskeletal ultrasound is very seldomly performed (9.47%). These doctors are thought to have a special interest in Sports Medicine.

Although there are regional differences regarding which procedures are performed, we agree with Wigton[67], who did similar work regarding procedures relevant to internal medicine, that there should be a core of procedural skills that family physician residents require. Wigton[67] defined this core to be those procedures, which are performed by over 90% of general practitioners.

If we apply this rule to our study, the following procedures may be considered as core procedures: oro/nasotracheal intubation, vascular access: peripheral arm veins, intercostal drain insertion, lumbar puncture, epistaxis and nasal packing, rectal examination, vaginal examination, chest X-Ray, abdominal X-Ray, pelvic X-Ray and neck X-Ray.

It is however important that more factors need to be considered regarding selecting a core set of procedures. These include the apparent life saving nature of the procedure, the complications and difficulties involved, the essentiality of the procedure in the practice situation as well as the comfortability of the family physician performing the procedure. The high number of procedures performed as revealed by the present study, reflect an enormous continuing educational challenge for family practice as a profession.

5.1.2 Frequency of performance

Procedures with a high frequency of performance (> 20 per annum) include:

- **Emergency procedures:** Vascular access via peripheral arm veins (91.58%)
  Oro/nasotracheal intubation (52.63%)
  Lumbar puncture (42.11%)
  Eye injury examination (42.11%)

- **Surgical procedures:** Dilatation and curettage (49.47%)
  Cesarian section (41.05%)
  Normal vaginal delivery (35.79%)
  Reduction of uncomplicated forearm fractures (29.47%)
  Circumsicion (25.26%)

- **Office procedures:** Vaginal examination (95.79%)
  Rectal examination (82.11%)
  Aspiration of pleural effusion (31.58%)

- **Imaging procedures:** Chest X-ray (86.32%)
  Abdominal X-ray (75.79%)
  Pelvic X-ray (68.42%)
  Neck X-ray (65.26%)
  Obstetric ultrasound (44.21%)

One expects general practitioners to be reasonably proficient in the performance of these procedures. This may however not be the case with all these procedures for the following were actually selected as problem procedures: oro/nasotracheal intubation, lumbar puncture, cesarian section, reduction of uncomplicated forearm fractures, rectal examination and obstetric ultrasound. The frequency of performance is therefore not an indication of the proficiency with a certain procedure.

Procedures with a lower frequency of performance (< 5 per annum) include (percentage represents the doctors performing this procedure not more than 5 times per annum):

- **Emergency procedures:** Vascular access via the great saphenous vein (74.07%)
  Cricothyroidotomy (23.16%)
  Subclavian vein catheterization (32.63%)
  Internal jugular vein catheterization (29.47%)
  Pretibial intraosseus puncture/infusion (27.37%)
  Suprapubic puncture and catheterization (29.47%)
  Umbilical line placement (26.32%)

- **Surgical procedures:** Appendectomy (21.05%)
  Ectopic pregnancy surgery (26.32%)

- **Office procedures:** Reduction of shoulder dislocation (32.63%)
  Epistaxis and nasal packing (29.47%)
  Reduction of elbow dislocation (27.37%)

Paronychia incision and drainage (23.16%)

- **Imaging procedures:** Nil

These procedures are therefore performed by most doctors but not more than five times a year. This may be a compromising factor in competency. However, Wigton[68] states that the number of procedures done per annum does not reflect proficiency in performing the procedure.

This notion is underscored by our data for a number of procedures with a high frequency of performance where selected as problem procedures as some with a lower frequency of performance where not selected as problem procedures. Usually the number of procedures that need to be done before attaining competency, is higher than the recommendations of expert panels. Few studies have attempted to determine how many supervised performances of a procedure are necessary to provide competence. It is difficult to know for any procedure what amount of experience and supervision is needed to attain competency[41]. The old saying of "see one, do one, teach one", is simply not good enough for competency.

In a study by Hawes *et al* [69], it was found that for acquiring competency in flexible sigmoidoscopy, 24-30 procedures are required. Competency in their study included correct insertion distance, number of lesions correctly identified and number of correct diagnoses and management scores.

5.1.3 Importance rating

- **Emergency procedures**

Procedures that were rated as essential by more than 60% of general practitioners were in order:

Vascular access via the peripheral arm veins (98%)
Intercostal drain insertion (86%)
Oro/nasotracheal intubation (85%)
Eye injury examination (80%)
Lumbar puncture (77%)
Suprapubic puncture and catheterization (66%)
Arterial puncture (62%)

Alarming is that less than 50% thought that a life saving procedure such as cricothyroidotomy (47%) was essential and nearly 10% thought it was not necessary.

Although less than 50% thought that vascular access via the great saphenous vein (37%) was an essential procedure, nearly 30% thought the procedure is useful and 24% thought the procedure is desirable. This reflects the fact that alternative vascular approaches like peripheral arm veins and the femoral vein is attempted before the great saphenous vein.

The insertion of a pretibial interosseous infusion was regarded by 51% to be an essential procedure. This certainly reflects the importance of this procedure regarding the rehydration of dehydrated children in hospital practice in the three studied provinces of South Africa and is a very specific finding as this procedure is rarely, if ever, performed outside a pediatric specialist unit in the United Kingdom or United States of America.

The high rating of the importance of emergency procedures by general practitioners reflects their important role in emergency care in hospital practices in the three studied provinces in South Africa. One reason for this certainly is the important role of the family physician's responsibility as the primary health worker of the unselected patient. Another reason for this may be due to amongst other factors, the high emergency patient load seen at hospital practices that has recently been reported[70].

- **Surgical procedures**

Surgical procedures that were rated as essential by more than 60% of general practitioners were in order:

Dilatation and curettage (76%)
Normal vaginal delivery (71%)
Reduction of uncomplicated forearm fractures (70%)
Cesarian section (67%)
Episiotomy (67%)
Ectopic pregnancy surgery (65%)

Sigmoidoscopy and proctoscopy was rated as essential by only 30% of general practitioners. This may be due to the fact that these procedures were not separated in the questionnaire, for more general practitioners may possibly rate a proctoscopy as more essential when compared to a sigmoidoscopy.

Although only 39% of general practitioners reported to perform an appendectomy, nearly 50% thought it is an essential procedure to perform. This reflects the need to perform this procedure although it is not as often performed. It may be explained by the fact that only 30% feel comfortable with performing an appendectomy, as well as 23% reporting difficulties due a lack of practical skills. A percentage of 51 thought that improving anatomy knowledge necessary to perform an appendectomy will increase their confidence in performing the procedure and 50% thought that it will reduce difficulties and complications. There does therefore exist a great educational challenge regarding the performance of an appendectomy.

Regarding invasive regional anesthetic procedures, both pudendal nerve block (19%) and brachial plexus block (20%) seem not to be regarded as essential by most general practitioners.

- **Office procedures**

Office procedures that were rated as essential by more than 60% of general practitioners

were in order:

Rectal examination (96%)
Vaginal examination (95%)
Epistaxis and nasal packing (82%)
Reduction of shoulder dislocation (67%)
Knee joint aspiration (60%)

Only 23% regarded shoulder joint injection to be essential, although 25% regarded the procedure as useful. This is not surprising, for injection of the shoulder joint is an important part of the treatment and diagnosis of shoulder joint problems, but certainly not essential.

The same is true for upper gastrointestinal endoscopy, liver biopsy, bone marrow aspiration and slit lamp examination, where only 20%, 18%, 30% and 18% respectively thought the procedure to be essential, but 30%, 26%, 18% and 25% respectively regarded the procedure as useful.

Surprisingly only 27% of general practitioners regarded an indirect laryngoscopy and only 24% a nasopharyngoscopy as essential. These procedures are important in the primary diagnostic investigation of suspected vocal cord and nasopharynx pathology respectively. It seems that the role of these procedures need more emphasis in teaching programs.

Wrist and digital nerve block was rated by nearly half (48%) of doctors to be essential and only by 8% as not necessary. This reflects the high expectation of general practitioners to manage hand injuries.

- **Imaging procedures**

Imaging procedures that were rated as essential by more than 60% of general practitioners were in order:

Chest X-ray (88%)
Neck X-ray (88%)
Abdominal X-ray (86%)
Pelvic X-ray (82%)

Obstetric ultrasound was regarded by 58% as essential and 26% as desirable which with the high performance rate (82%) of the procedure, illustrates the fact that this procedure is regarded as an important one in hospital practice in the studied three provinces in South Africa, an issue that is often debated[71].

5.1.4 Measure of comfort rating

Although it may be argued that a score that rates how comfortable a family physician is with his own performance of a procedure may be seen as very subjective, it does provide important information on self assessment of proficiency and identifying what may be

called problem procedures. This rating does not point to where the exact problem is, whether there is a deficiency regarding knowledge or skills, but is does provide a global self-assessment. The results of this study compares well with a Canadian study[72] where Canadian general practitioners reported not to feel comfortable in performing procedures such as simple fracture reduction, intravenous access, lumbar puncture and endotracheal intubation.

- **Emergency procedures**

Although 96% of family physician perform oro/nasotracheal intubation, only 51% regard themselves as being very comfortable with the procedure.

This is even more striking for cricothyroidotomy, where 26% reported to perform the procedure, but only 1% regard themselves as very comfortable with this life saving procedure and 32% as uncomfortable and very uncomfortable.

The same is true for pericardiocentesis and vascular access via the great saphenous vein, where 23% and 57% respectively report to perform the procedure, but only 3% and 12% respectively regard themselves to be very comfortable with the procedure and 32% and 22% as uncomfortable and very uncomfortable respectively.

Similar results were observed for subclavian vein catheterization, internal jugular vein catheterization and pretibial interosseous puncture/infusion where 57%, 45% and 41% perform the procedure respectively, but only 12%, 8% and 12% regard themselves to be very comfortable with the procedures and 27%, 30% and 20% as uncomfortable and very uncomfortable with the respective procedures.

These figures reflect a high incidence of performance, but not necessarily a high comfortability score, which amongst other reasons may reflect on the underlying anatomy necessary to perform a safe and successful procedure. They should be regarded as problem procedures and therefore receive priority in continued educational procedural training.

The incidence of vascular access via the peripheral arm veins is very high (100%). A Measure of comfort rating of only 2% being uncomfortable with the procedure correlates well with the high incidence.

The same can be said for intercostal drain insertion and lumbar puncture, where 91% report to perform both procedures and only 3% and 4% respectively report to be uncomfortable and very uncomfortable with the procedure.

Regarding eye injury examination, most general practitioners report to be fairly comfortable (56%).

Procedures where more general practitioners felt uncomfortable (score of uncomfortable plus very uncomfortable) than comfortable (score of comfortable plus very comfortable)

were: cricothyroidotomy, pericardiocentesis and internal jugular vein catheterization. These procedures are indeed of a life saving nature and also carry high-risk anatomically related complications if performed incorrectly.

- **Surgical procedures**

Although 69% of general practitioners perform reduction of uncomplicated forearm fractures, only 30% report to be very comfortable with the procedure.

Similar findings were true for the performance of a normal vaginal delivery, cesarian section, ectopic pregnancy surgery and appendectomy, where 79%, 75%, 55% and 39% of general practitioners respectively reported to perform the procedures and only 47%, 42%, 28% and 12% of general practitioners respectively, report to be very comfortable with the procedures.

These figures reflect a relatively high incidence of performance, but not necessarily a high comfortability score, which amongst other reasons may reflect on the underlying anatomy necessary to perform a safe and successful procedure. They should be regarded as problem procedures and therefore receive priority in continued educational procedural training.

The high rate of no response to this assessment found for especially pudendal nerve block (68%), brachial plexus block (59%) and tonsillectomy and adenoidectomy (58%) correlates well with the low performance rate of these procedures, 16%, 17% and 27% respectively.

Procedures where more general practitioners felt uncomfortable (score of uncomfortable plus very uncomfortable) than comfortable (score of comfortable plus very comfortable) were: sigmoidoscopy and proctoscopy, appendectomy, pudendal nerve block and brachial plexus block.

- **Office procedures**

The performance rate of both rectal and vaginal examination was extremely high as expected, 98% and 99% respectively. A Measure of comfort rating of 0% and 2% respectively as being very uncomfortable correlates well with the high incidence. There seems however to be more doctors to be very comfortable with vaginal examination (90%) compared to rectal examination (86%).

Although 79% of general practitioners perform knee joint aspiration, only 48% report to be very comfortable with the procedure.

The same is true for the performance of wrist and digital nerve block, shoulder joint injection, epistaxis and nasal packing, aspiration of pleural effusion, reduction of shoulder dislocation, reduction of elbow dislocation, reduction of interphalangeal joint dislocation and reduction of hip joint dislocation. Table 31 illustrates the figures.

Procedure	Performance rate	Comfortable (very comfortable and fairly comfortable)
Wrist and digital nerve block	58%	52%
Shoulder joint injection	29%	23%
Epistaxis and nasal packing	96%	85%
Aspiration of pleural effusion	85%	85%
Reduction of shoulder dislocation	81%	68%
Reduction of elbow dislocation	54%	44%
Reduction of interphalangeal joint dislocation	65%	60%
Hip joint dislocation	28%	20%

Table 31. Office procedures with a high incidence of performance but significantly lower measure of comfort rating.

These figures reflect a relatively high incidence of performance, but not necessarily a high comfortability score, which amongst other reasons may reflect on the underlying anatomy necessary to perform a safe and successful procedure. They should therefore be regarded as problem procedures and receive priority in continued educational procedural training.

Procedures where more general practitioners felt uncomfortable (score of uncomfortable plus very uncomfortable) than comfortable (score of comfortable plus very comfortable) were: colposcopy, upper gastrointestinal endoscopy, liver biopsy, reduction of hip joint dislocation, nasopharyngoscopy and slit lamp examination.

- **Imaging procedures**

Although a high performance rate is reported for a number of imaging procedures, a significantly lower number of doctors report to be very comfortable with the procedures. This is illustrated in Table 32.

Procedure	Performance rate		Comfortable (very comfortable and fairly comfortable)
Chest X-ray	93%	Interpretation	89%
Abdominal X-ray	94%		86%
Pelvic X-ray	93%		82%
Neck X-ray	92%		78%
Obstetric ultrasound	82%	Performance and interpretation	67%
Abdominal ultrasound	59%		37%

Table 32. Imaging procedures with a high incidence of performance but significantly lower measure of comfort rating.

Especially regarding obstetric ultrasound and abdominal ultrasound these figures does raise concern regarding the very high performance rate, but relative uncomfortability with which these procedures are performed, with 19% and 28% reporting to be uncomfortable and very uncomfortable respectively for these two procedures.

These figures reflect a very high incidence of performance, but not necessarily a high comfortability score, which amongst other reasons may reflect on the underlying anatomy necessary to perform a safe and successful procedure. They should also be regarded as problem procedures and therefore receive priority in continued educational procedural training.

The low rate of interpretation of both abdominal and brain CT scans by general practitioners, correlates well with the high assessment of doctors being uncomfortable and very uncomfortable with interpreting these scans, 24% and 28% respectively. This is not surprising, as these imaging procedures are usually interpreted by specialists in hospital practices where CT scanners are available, which in our study is limited to the Kalafong and Pretoria Academic Hospitals.

Procedures where more general practitioners felt uncomfortable (score of uncomfortable plus very uncomfortable) than comfortable (score of comfortable plus very comfortable) were: musculoskeletal ultrasound, abdominal CT scan and brain CT scan.

5.1.5 Difficulties of performance

Four categories of difficulties were defined and assessed for all the procedures. They are i) knowledge of the procedure, ii) practical skills, iii) equipment necessary and iv) regional anatomy knowledge. Especially knowledge of the procedure, practical skills and regional anatomy knowledge are interrelated, as anatomical knowledge is a key feature to

the procedural skill exercised. Clinically relevant anatomy related to the specific procedure cannot be separated from practical skills with which a procedure is performed[21].

The no response option was rated relatively high in most procedures. This could be interpreted in several ways. The most likely explanation is that it represents the fact that no difficulty mentioned was experienced concerning the specific procedure. It may however also reflect a degree of uncertainty in what is actually meant by the difficulties mentioned. Although the options "equipment necessary" and " regional anatomy knowledge" seem straight forward, the options " knowledge of the procedure" and "practical skills" may be widely interpreted. Thirdly non-respondents may think they have no difficulty with the procedure, but may actually have some difficulties after being specifically alluded to it. An example is for instance the no response reported for injury of the saphenous nerve related to a venous cutdown of the great saphenous vein. It can be argued that few respondents actually are aware of this nerve and therefore are unaware of its possible injury when performing a cutdown.

- **Emergency procedures**

Practical skills were reported in most procedures and by most doctors as the greatest difficulty. These included the following procedures: oro/nasotracheal intubation (23%), cricothyroidotomy (23%), vascular access via the femoral vein (22%), subclavian vein catheterization (30%), intercostal drain insertion (20%), lumbar puncture (16%), arterial puncture (20%), pericardiocentesis (20%) and umbilical line placement (21%).

Knowledge of the procedure was reported to be the greatest difficulty in vascular access via the great saphenous vein (20%).

Equipment necessary to perform the procedure, was regarded as the greatest difficulty in pretibial interosseous puncture, suprapubic puncture and catheterization and eye injury examination. This is most probably due to the unavailability of specialized needles for the performance of pretibial interosseous punctures and suprapubic catheterization, as well as the availability of a good light source for eye examination.

Regional anatomy knowledge was regarded as a difficulty in especially the following procedures: eye injury examination (20%), subclavian vein catheterization (16%), vascular access via the great saphenous vein (13%), lumbar puncture (12%) and internal jugular vein catheterization (13%).

This should however be placed in the perspective of the very strong indication given by the vast majority of doctors that improvement in the critical anatomy knowledge necessary to perform the procedures will reduce difficulties and complications and will increase confidence in performing the procedure (Tables 20 and 24).

- **Surgical procedures**

Practical skills were reported in most procedures and by most doctors as the greatest

difficulty: reduction of uncomplicated forearm fractures (29%), sigmoidoscopy and proctoscopy (28%), cesarean section (28%), sterilization (20%), ectopic pregnancy surgery (22%), excision of external hemorrhoids (25%), appendectomy (29%), tonsillectomy and adenoidectomy (22%), pudendal nerve block (16%) and brachial plexus block (20%).

This may reflect an underlying knowledge framework weakness which is integrally related to these skills amongst which anatomy is crucial.

Knowledge of the procedure was regarded to be the greatest difficulty in dilatation and curettage (13%) as well as circumsicion (17%).

Equipment necessary to perform the procedure was not regarded as a major difficulty in any of the surgical procedures.

Regional anatomy knowledge was regarded as a difficulty in especially the following procedures: brachial plexus block (16%), cesarean section (12%), reduction of uncomplicated forearm fractures (10%), pudendal nerve block (10%) and excision of external thrombosed hemorrhoids and injection or ligation of internal hemorrhoids (10%).
These figures appear to be low, but should however be placed in the perspective of the very strong indication given by the vast majority of doctors that improvement in the critical anatomy knowledge necessary to perform the procedures will reduce difficulties and complications and will increase confidence in performing the procedure (Table 21 and 25).

- **Office procedures**

Practical skills were reported in most procedures and by most doctors as the greatest difficulty: wrist and digital nerve block (24%), injection of shoulder joint (16%), colposcopy (17%), paronychia incision and drainage (13%), upper gastrointestinal endoscopy (14%), knee joint aspiration (18%), liver biopsy (21%), bone marrow aspiration (23%), aspiration of pleural effusion (15%), reduction of shoulder dislocation (26%), reduction of elbow dislocation (17%), reduction of interphalangeal joint dislocation (17%), reduction of hip dislocation (21%), nasopharyngoscopy (16%) and slit lamp examination (15%).
This lack or practical skills may not only reflect a manual skills deficiency to perform the procedure, but as important may reflect an underlying knowledge framework weakness, which is integrally related to these skills amongst which anatomy is crucial. The hands naturally do what the brain thinks[31].
Knowledge of the procedure was regarded to be the greatest difficulty in epistaxis and nasal packing (17%), rectal examination (12%) and vaginal examination (14%). This is not surprising, for the manual skills to perform these procedures is relatively straight forward, but the correct performance of these procedures, heavily depends on a sound knowledge base. The hands that are actually performing the procedures are entirely dependent on a spatial understanding of the relevant anatomy[73].

Equipment necessary to perform the procedure was regarded to be a problem in especially the following procedures: indirect laryngoscopy (16%), bone marrow aspiration (22%), nasopharyngoscopy (15%) and slit lamp examination (13%). This is most probably due to the unavailability of specialized instruments like a bone marrow aspiration needle, dental mirrors and a slit lamp.

Regional anatomy knowledge was regarded as a difficulty in especially the following procedures: wrist and digital nerve block (13%), knee joint aspiration (14%), epistaxis and nasal packing (12%) and rectal examination (12%). These figures appear to be low, but should be placed in the perspective of the very strong indication given by the vast majority of doctors that improvement in the critical anatomy knowledge necessary to perform the procedures will reduce difficulties and complications and will increase confidence in performing the procedure (Table 22 and 26).

- **Imaging procedures**

Practical skills were reported in most procedures and by most doctors as the greatest difficulty: abdominal X-ray (13%), pelvic X-ray (16%), neck X-ray (16%), obstetric ultrasound (23%) and abdominal ultrasound (30%). Concerning the latter two, this lack or practical skills may not only reflect a manual skills deficiency to perform the procedure, but as important may reflect an underlying knowledge framework weakness, which is integrally related to these skills amongst which anatomy is crucial. Regarding the interpretation of the X-rays, the lack of practical skills does reflect an underlying knowledge deficiency.

Equipment necessary to perform the procedure was regarded to be a problem in especially the following procedures: musculoskeletal ultrasound (17%), abdominal CT scan (20%), brain CT scan (18%). This is not surprising for these images are usually performed and interpreted by specialists in tertiary medical care centers.

Regional anatomy knowledge was regarded as a difficulty in especially the following procedures: brain CT scan (13%), chest X-ray (16%), pelvic X-ray (15%), neck X-ray (17%) and obstetric ultrasound (14%). These figures should be evaluated together with the very strong indication given by the vast majority of doctors that improvement in the critical anatomy knowledge necessary to perform the procedures will reduce difficulties and complications and will increase confidence in performing the procedure (Table 23 and 27).

5.1.6 Complications of performance (Table 20)

Due to the individual specificity of the complications of every single procedure, the most relevant and anatomically important complications were rated for every specific procedure (Table 20). Both the complication and the percentage of occurrence of the complication by all respondents are provided. Only the most striking results for every procedure are discussed here.

- **Emergency procedures**

Nearly half (47.4%) of general practitioners are not able to visualize the vocal cords relevant to ***oro/nasotracheal intubation***. This is a complication based on pure anatomical grounds, whether the vocal cords are not correctly identified or whether the skill to slide the laryngoscope blade into the correct position is the problem. It is therefore not surprising that esophageal intubation is also a highly rated complication (36.8%).

It is alarming that the most common complication found in ***cricothyroidotomy*** is the inability to find the correct entry site for the needle (8.4%). This may be regarded as basic surface anatomy of the midline structures of the neck, applied to the skill to find the cricothyroid membrane on a patient.

Brachial artery puncture (10.5%) remains an important complication regarding ***vascular access of peripheral arm veins*** due to its close relation to the cubital fossa veins deep to the bicipital aponeurosis. The high percentage of inability to locate a suitable vein (47.4%) is not suprising, as these veins are difficult to find in obese and hypovolemic patients. Other vascular access routes should therefore be explored.

Inability to locate the femoral vein during ***vascular access of the femoral vein*** is rated very high (33.7%). It is therefore not surprising that femoral artery puncture is also rated high (28.4%), as the femoral artery lies directly lateral to the femoral vein just below the inguinal ligament and the palpable pulse of the femoral artery forms the important landmark to find the femoral vein medial to it for successful cannulation.

Inability to locate the ***great saphenous vein for vascular access*** is rated high (32.6%). This skill is solidly based on an understanding of the surface anatomy of the vein anterior to the medial malleolus.

Regarding ***subclavian vein catheterization***, inability to locate the vein was regarded as the most common complication (45.3%), followed by subclavian artery puncture (12.6%) and a hemopneumothorax (9.5%). The surface anatomy of the vein and the correct direction of the needle is obviously the main concern. Inability to perform this correctly, will surely result in the complications listed. Failure to locate the vein at first, will therefore result in puncturing the subclavian artery posterolateral to the subclavian vein and the pleura posteroinferior to the subclavian vein.

Inability to locate the internal jugular vein was also regarded as the most common complication of ***catheterization of the internal jugular vein*** (37.9%). Correct location of the vein is based on a sound surface anatomical knowledge of the vein. It is therefore not surprising that due to incorrect location of the vein, related structures like the common carotid artery and pleura are injured, causing puncture of the artery (7.4%) and a pneumothorax (5.3%) respectively.

Inability to find the correct site of placement was rated to be a problem by 14.7% of general practitioners during ***pretibial intraosseous puncture/ infusion***, with possible

resultant physeal plate injury (3.2%). Correct placement is based on the surface anatomy of the insertion site of the intraosseous needle and the relations of structures to the inserted needle. Subcutaneous or subperiosteal infiltration reported by 15.8% is based on an understanding of where the needle actually goes and therefore a cross sectional anatomical understanding at the site of needle entry.

For the placement of an ***intercostal drain***, the inability to find the correct site of placement of the tube was reported by 16.8% of general practitioners. This explains the bleeding from intercostal vessels (17.9%), injury to the intercostal nerves (2.11%) and puncture of the intrathoracic and /or abdominal organs (5.3%). This is due to the fact that the correct identification of the site of insertion of the intercostal tube by means of surface anatomy knowledge can prevent injury to intercostal arteries, nerves and intrathoracic and/or intra-abdominal organs. A sound knowledge of the position of the neurovascular bundle on the inferior surface of the ribs avoids placing the tube over the inferior surface of the rib instead of its superior surface.

Inability to find the correct entry site for placement of the needle during ***lumbar puncture*** (33.7%), is the result of a lack of understanding of the surface anatomy of the spinal cord and insertion site. Unawareness of the structures in relation to the advancing needle and therefore the cross sectional anatomy of the lumbar spine, explains the inability to appreciate the position of the advancing needle (15.8%) and the common complication of a bloody tap (45.3%) if the needle is placed too lateral with injury to the posterior external vertebral venous plexus in the epidural space.

Unawareness of the surface anatomy of both the radial and femoral arteries, explains the inability to locate the radial artery (20%) and femoral artery (6.3%) during an ***arterial puncture for arterial blood sampling.*** Lack of knowledge explains the uncertainty on which artery to use in pediatric patients (22.1%) as it is absolutely contraindicated to use the femoral artery in children due to the risk of thromboembolism and causing a septic hip arthritis due to the posterior relation of the hip joint to the femoral artery at the entry site of the needle[74].

Lack of surface anatomy and cross sectional anatomical understanding at the plane of needle entry, explains the inability to find the correct site of placement (10.5%) and inability to appreciate the position of the advancing needle (18.9%) respectively, during the performance of a ***pericardiocentesis***.

Unawareness of the cross sectional anatomy of the umbilical cord explains the 21.1% of general practitioners unable to find the umbilical vein during an ***umbilical line placement***.

Lack of understanding of abdominal surface anatomy as well as the extent and reflection of the peritoneal layers, explains the uncertainty about the site of placement of a suprapubic needle (17.9%) and intra-abdominal placement (10.5%) during ***suprapubic puncture and catheterization.***

Uncertainty on the functional anatomy of the eye explains the inability to examine the eye properly by visualizing the retina and optic disc (37.9%), during ***examination of the injured eye.***

- **Surgical procedures**

Uncertainty on the osteology and radiographic anatomy of the wrist before and after reduction explains why 39% of doctors are unsure about correct reduction during ***reduction of uncomplicated forearm fractures.***

Lack of endoscopic anatomical knowledge of the sigmoid colon, rectum and anus is the reason why 10.5% are unsure of the differences between these structures and 7.4% are unsure of the anatomy of the bowel mucosa, during the performance of a ***sigmoidoscopy and proctoscopy.***

Uncertainty about the anatomy of the uterus leads to the unawareness of 15.8% of general practitioners about the extent of the uterus in a non pregnant female during the performance of ***dilatation and curettage***. This explains why 19% of doctors experience uterus perforations.

Uncertainty about the perineal layers when suturing an ***episiotomy*** by 16.8% of doctors is based on a lack of understanding of the perineal anatomy.

Lack of knowledge of the basic pelvic anatomy as applied to obstetrics, explains the uncertainty about anatomical landmarks during vaginal examination, reported by 9.5% of doctors during ***normal vaginal delivery***. This will naturally explain the uncertainty about determining the position of the fetal head in 13.7%. Although vaginal tears are a recognized complication of normal vaginal delivery, the reported 28.4% second or third degree tears is high, possibly reflecting lack of practical skills to support the perineum during fetal head delivery.

Uncertainty of the anterior abdominal layers as seen during a Pfannenstiel incision may explain the 27.8% of doctors having difficulty to perform this incision for access during the performance of a ***cesarean section***. This also explains the uncertainty about the anatomy of the abdominal wall when suturing in 7.4%. Lack of understanding of the relational anatomy of the pregnant uterus explains the difficulty to determine the site of uterine incision by 9.5% and injury to the ureter by fortunately a relatively low 4.2% of doctors.

Difficulty to understand the pelvic anatomy as seen from the pelvic inlet and undamaged peritoneum as well as blood supply to the uterine tubes, explains the problem to locate the uterine tubes experienced by 36.8% of doctors and bleeding by 13.7% respectively during the performance of a ***sterilization.***

Uncertainty about the blood supply of the uterine tubes and anastomosis between the

ovarian and uterine arteries may in part explain the high incidence of bleeding experienced by 29.5% doctors during the performance of ***ectopic pregnancy surgery***.

Lack of knowledge of both the arterial supply and venous drainage of the foreskin as well as the blood vessels associated to the frenulum of the foreskin, explains the bleeding reported at the high rate of 33.7% of doctors during a ***circumcision.***

Uncertainty about what hemorrhoids actually are as well as their normal anatomical location, explains the difficulty 7.4% of doctors have to distinguish between hemorrhoids as well as the 17.9% who are unsure of the site of incision during the excision of ***external thrombosed hemorrhoids and injection or ligation of internal hemorrhoids.***

Unawareness of the different possible positions of the appendix and uncertainty of the surface anatomy of this structure explains why 23.3% of doctors are unable to locate the appendix and 7.4% are unsure of the site of incision during the performance of an ***appendectomy.***

Uncertainty on the tonsillar and peritonsillar vessels as well as the fascial planes around the palatine tonsil, explains partly why 27.4% of doctors experience bleeding and why 8.4% are unable to remove the tonsil in the fascial plane respectively during a ***tonsillectomy and adenoidectomy***.

Lack of knowledge of the position and surface anatomical landmarks to advance a needle towards the pudendal nerve during a ***pudendal nerve block*** is the reason why 20% of doctors are uncertain how to find the nerve.

Lack of knowledge of the position of the brachial plexus and the surface anatomical landmarks to locate different parts of the brachial plexus during ***regional brachial plexus blockade***, explains the uncertainty about the site of entrance and direction of the needle experienced by 16.8% of doctors. Due to the uncertainty of the direction of the needle, it is actually surprising that only 3.16% of doctors report a pneumothorax and phrenic nerve paralysis, due to the relational anatomy of the pleura and phrenic nerve to the brachial plexus. The latter is more prone to injury during interscalene blockade, where the C5,6 roots of the brachial plexus are anesthetized.

- **Office procedures**

Failure to appreciate the relational anatomy of the nerves around the wrist and digits, explains the inability to locate the nerves in relation to the wrist and digits by 15.8% and 14.7% of doctors respectively during ***wrist and digital nerve blockade***.

Uncertainty of the surface anatomy of the shoulder and extent of the shoulder joint explains the problem of finding the site of entrance and direction of the needle by 20% of doctors during ***injection of the shoulder joint***.

Uncertainty about the anatomical landmarks was reported by 9.8% doctors during the

performance of a ***colposcopy,*** which relates to the anatomy of the cervix as seen through a speculum.

Uncertainty about the surgical anatomy involved during ***paronychia incision and drainage*** explains the uncertainty about the site of incision by 19% of doctors.

A percentage of 8.42 of doctors who perform ***upper gastrointestinal endoscopy*** report to be unsure about anatomical landmarks of the mucosal anatomy and reveals a lack of understanding of the endoscopic anatomy of the gastrointestinal tract.

Inability to appreciate the surface anatomy of the knee and the underlying structures, explains the inability to locate the site of entry by 13.7% and injury to the articular cartilage by 9.5% of doctors respectively during a ***knee joint aspiration***.

Failure to appreciate the surface anatomy of the liver, especially as seen on the midaxillary line, explains the uncertainty of 15.8% of doctors to locate the site of entrance needed during performance of a ***liver biopsy***.

Uncertainty on the endoscopic anatomy of the laryngopharynx and larynx, explains the uncertainty about anatomical landmarks by 10.5% of those who perform an ***indirect laryngoscopy***.

Inability to control bleeding by 47.4% of doctors during ***epistaxis and nasal packing*** may be due to a lack of practical skills and therapeutic knowledge of which both are supported by a sound understanding of the blood supply of the nasal septum and lateral walls of the nose.

Uncertainty on the surface anatomy of the bony points where a ***bone marrow aspiration*** can be performed explains the 20% of doctors who are not sure about the site of needle entry.

Lack of knowledge of the surface anatomy of the lung and pleural reflections result in uncertainty about the site of needle entrance reported by 14.7% of doctors during ***aspiration of a pleural effusion***.

Uncertainty of the functional anatomy of the shoulder joint and biomechanics of a shoulder dislocation as well as relational anatomy of a dislocated humerus head to the brachial plexus, explains the uncertainty about the technique and its rationale during ***reduction of shoulder joint dislocation*** by 21.1% of doctors and brachial plexus injuries by 7.4% of doctors respectively.

The same functional anatomical uncertainty on the elbow joint , interphalangeal joints and hip joint regarding the biomechanics of dislocation of these joints explains the uncertainty about the technique to relocate these joints by 16.8% of doctors regarding the ***reduction of elbow dislocation***, 10.5% regarding the ***reduction of interphalangeal joint dislocation*** and 17.9% regarding the ***reduction of hip joint dislocation***.

Failure to appreciate the endoscopic anatomy of the nasopharynx was reported by 12.6% of doctors performing a ***nasopharyngoscopy***. This is due to a lack of understanding of the different normal mucosal folds in the nasopharynx and what they represent.

Uncertainty about the anatomy of eye structures was reported by 13.7% of doctors performing a ***slit lamp examination***. This is due to unfamiliarity with the anatomy of the eye as seen via this technique.

Inability to appreciate the spatial anatomy of the rectum as applied to ***rectal examination*** explains the 30.5% of doctors who are unable to locate the seminal vesicles, the alarming 9.5% who are unable to locate the prostate gland and the 5.3% who are unable to locate the cervix and uterus in a female patient. It may indeed be difficult to palpate the seminal vesicles as is reflected by the high reported figure, but inability to palpate the prostate is alarming.

Likewise, inability to appreciate the spatial anatomy of the vagina as applied to a ***vaginal examination***, explains the 7.4% of doctors who are unable to locate the bladder, the 5.3% who are unable to locate the adnexal structures, the 6.3% unable to locate the recto-uterine pouch and the 21.1% unable to appreciate the position of the ureters. Although the position of the ureters as appreciated by a vaginal examination is difficult, the location of the bladder, adnexal structures and recto-uterine pouch is vitally important during a vaginal examination.

- **Imaging procedures**

Failure to appreciate the ultrasonographic anatomy of specific muscles and bony structures, explains the inability to locate them by 12.6% of doctors performing a ***musculoskeletal ultrasound***.

Inability to appreciate cross sectional anatomy of the abdomen and skull, explains the reported inability to read an ***abdominal and brain CT scan*** by 13.7% of doctors who interpret these scans.

Failure to appreciate the radiographic anatomy of the thorax explains why 3.2% of doctors are unable to locate the borders of the heart, 4.2% to count the ribs and 19% to visualize the pulmonary vasculature on a ***chest X-ray***. Although these figures are not extremely high, it shows how problematic can be the simple interpretation of normal anatomy on an X-ray.

Failure to appreciate the radiographic anatomy of the abdomen explains why 10.5% of doctors are unable to differentiate small bowel from large bowel, 7.4% are unsure about the soft tissues and 22% are unable to visualize the psoas line on an ***abdominal X-ray***. These figures are actually quite high, keeping in mind that these elements are key features in interpreting an abdominal X-ray.

Inability to locate the bony landmarks by 11.6% and evaluate the pelvic brim by 7.4% of

doctors on a ***pelvic X-ray***, shows that there are conceptual deficiencies in the simple interpretation of the radiographic anatomy on a pelvic X-ray.

Failure to assess the soft tissue spaces by 21.1% and the bony landmarks by 19% of doctors on a ***neck X-ray***, is extremely alarming and shows great incompetence to read the radiographic anatomy on a neck X-ray. The great importance of being able to interpret a neck X-ray properly is of life-saving nature as is underscored by the American College of Surgeons[75].

The inability to locate anatomical structures by 34.7% of doctors and to understand how obstetric measurements are done by 16.8% during the performance of an ***obstetric ultrasound*** is alarming in the light of the fact that 82% of doctors report to perform this procedure. This is explained by a basic lack of understanding of the ultrasonographic anatomy of pregnancy.

The failure to locate anatomical structures by 34.7% of doctors during the performance of an ***abdominal ultrasound*** is problematic, especially because of the fact that 59% of doctors report performing this procedure.
For both the obstetric and abdominal ultrasound it in effect means that a third of doctors performing these procedures are unable to identify with certainty the structures they are looking at. This raises serious doubts about the reliability and validity of these procedures in family physician's hands.

It is clear that nearly all complications mentioned above arise from a lack of understanding of basic surface, surgical, functional, radiographic, cross sectional, relational and endoscopic anatomy.

5.1.7 The role of clinical anatomy in reducing difficulties and complications

Previous studies have ranked the importance of anatomy with regard to common health problems. Adeyemi-Doro[76] did a study amongst doctors, rating the relevance of anatomy to the diagnosis and treatment of 40 listed health problems. No study has however been undertaken to rate the assessment of general practitioners on the influence of clinical anatomy on the safe and successful performance of procedures in hospital practice and whether the improvement of clinical anaotomy knowledge may actually reduce difficulties and complications.

- **Emergency procedures**

Regarding emergency procedures (Table 21), more than 80% of doctors agreed (strongly agree + agree) in *all* procedures that the improvement of critical anatomy knowledge necessary to perform this procedure will reduce difficulties and complications.

The three procedures where the strongest agreement with the statement was reported were: subclavian vein catheterization (63% strongly agree), eye injury examination (60% strongly agree) and cricothyroidotomy (57% strongly agree).

Regarding vascular access of peripheral arm veins, 15% of doctors disagreed (strongly disagree plus disagree) with the statement. This reflected the strongest disagreement with the statement of all the emergency procedures and is not surprising considering that the procedure is performed by 100% of the general practitioners and usually has few complications.

These figures reflect not only a great need for postgraduate clinical anatomy teaching but also more importantly the possible influence of improvement of relevant anatomy regarding specific procedures in reducing difficulties and complications and therefore have an enormous influence on patient care.

Although these figures represent a subjective self-assessment, it does reflect the notion and strong message of practitioners in the field. This is an important first step on the road of illustrating the key significance of anatomy on patient care regarding clinical procedures.

This has to be followed up by assessment on the influence of anatomy on patient care on higher levels of the assessment pyramid of Miller[54] by means of content based written and performance based assessment.

- **Surgical procedures**

Regarding surgical procedures (Table 22) more than 85% of all doctors agreed and strongly agreed in *all* procedures that the improvement of critical anatomy knowledge necessary to perform this procedure will reduce difficulties and complications.

This is an extremely strong message regarding their perception of the influence of anatomy knowledge on competent performance of surgical procedures.

The three procedures where the strongest agreement with the statement was reported, were (strongly agree plus agree): cesarean section (94%), appendectomy (94%) and pudendal nerve block (94%). Especially the first two procedures are highly invasive and certainly need a very competent level of anatomical knowledge.

- **Office procedures**

Regarding office procedures (Table 23), more than 80% of all doctors agreed and strongly agreed in *all* procedures that the improvement of critical anatomy knowledge necessary to perform this procedure will reduce difficulties and complications.
This is a very strong message to underscore the notion that competency in anatomy is also of great importance in the safe performance of less invasive office procedures.

The four procedures where the strongest agreement with the statement was reported, were (strongly agree plus agree): reduction of shoulder joint dislocation (96%), reduction of elbow joint dislocation (95%), wrist and digital nerve block (95%) and knee joint aspiration (94%).

These procedures are indeed associated with complications which are anatomically related, and therefore require a higher anatomical competency to perform safely.

- **Imaging procedures**

Regarding imaging procedures (Table 24), more than 79% of all doctors agreed and strongly agreed in *all* procedures that the improvement of critical anatomy knowledge necessary to perform this procedure will reduce difficulties and complications.

The three procedures where the strongest agreement with the statement was reported, were (strongly agree plus agree): abdominal ultrasound (95%), obstetric ultrasound (91%) and neck X-ray (91%).
Interpreting these image procedures without difficulty does indeed need a high competency level of radiographic and ultrasonographic anatomy.

5.1.8 The role of clinical anatomy to increase the confidence of general practitioners in performing procedures

It is widely recognized that the degree of confidence to perform a procedure is reflected amongst others by competency in the anatomy relevant to the specific procedure. Ger[11] has pointed out that prolongation of surgical procedures is partly but most importantly due to the incompetent anatomical knowledge of the surgeon which is reflected in a lack of confidence. This may have detrimental consequences to the patient.

This present study proves beyond any doubt that doctors agree with this notion.

For emergency procedures (Table 25), more than 80% of doctors agreed and strongly agreed that improvement of anatomical knowledge relevant to the procedure will increase confidence in performing the procedure. This was also true for surgical procedures (Table 26), office procedures (Table 27) and imaging procedures (Table 28).

The notion was most strongly supported regarding eye injury examination (93%), cricothyroidotomy (88%) and both subclavian and internal jugular vein catheterization (88%) for emergency procedures. For surgical procedures, the notion was most strongly supported regarding pudendal nerve block (95%), brachial plexus block (94%), appendectomy (92%) and cesarian section (91%).The notion was most strongly supported for office procedures regarding reduction of elbow joint dislocation (95%), reduction of shoulder joint dislocation (94%), knee joint aspiration (94%) and wrist and digital nerve block (94%).

For imaging procedures, the notion was most strongly supported regarding abdominal ultrasound (95%), obstetric ultrasound (94%) and neck X-ray (88%).

All these figures correlate very strongly with the notion that improvement of anatomy knowledge necessary for a specific procedure will reduce difficulties and complications.

5.2 Selection of problem procedures and criteria for selection

A total of 15 problem procedures were selected (Table 29) according to scoring option C to obtain a representative number of procedures in every category (emergency, surgical, office and imaging procedures) where clinical anatomy competence is the most obvious problem in dealing with difficulties and complications and where improvement of this competence will result in improved patient care.

Six procedures where selected under the category of emergency procedures. Due to the anatomical overlap involved during subclavian vein and internal jugular vein catheterization, they were grouped together under one as central venous catheterization.

For the categories surgical and office procedures, four procedures were selected for each category. Similarly due to the anatomical similarities involved during rectal examination and proctoscopy and sigmoidoscopy, these procedures were grouped together. Both obtained high scores during the selection process.

One procedure was selected for the category imaging procedures.

Determining the scope of different clinical procedures done by family practitioners is significant. Not only the teachers of a discipline should be consulted to determine content, but also those who practice the discipline. Spivey[63] has developed a method to use a formal survey to determine content. Spivey's method has also been successfully applied in determining which procedural skills should be learned by internal medicine residents[77]. The data presented in this study may be of significance in determining which procedures need to be included not only in postgraduate anatomical education, but also in family practice residency programs in South Africa.

Most clinical anatomy training programs for residents of any specialty are usually based on a regional anatomy approach of the relevant area. Most programs usually do not focus on the specific needs of the specialty involved. This is certainly true for the postgraduate clinical anatomy training program of general practitioners[13].

It is thought that in the 'age of evidence based medical education', it is vitally important to focus clinical anatomy training programs on actual data from clinical practices. The anatomy general practitioners need to practice at the bedside is often determined by what clinical anatomists think general practitioners need to know. There is often an assumption of what anatomy is needed by general practitioners to perform clinical procedures. However, the evidence base of what we are teaching is usually absent. There is therefore a need to support our teaching programs with hard data from the field in order to contribute to patient care. South African medical schools are challenged in the training of general practitioners to cater for both first and third world patient populations. The crucial challenge is to succeed in directing the medical education obligation to the entire population[78].

Boon *et al* [16] demonstrated that clinical anatomy training programs should focus on four

basic elements of clinical practice in order to equip physicians with a sound anatomical base for safe clinical practice. These are the clinical examination, radiographic interpretation, clinical procedures and clinical reasoning skills. These elements are core to medical practice and anatomy training programs should always keep these elements in mind. This study focuses on one element, namely the clinical procedures.

Certainly in the South African context, an evidence base for the procedures done in hospital practice is not available. This study addresses this question and also studies the difficulties and complications experienced during performance of various clinical procedures. These are usually greatly dependent on a sound anatomical understanding. It seems this is a first study determining the evidence base for a clinical anatomy procedures training program for general practitioners in hospital practice in a developing country. The procedures performed were systematically determined, difficulties and complications related to the anatomy were identified. This formed the basis to develop a clinical anatomy knowledge base for problem practical procedures and a training program for general practitioners.

5.3 Comparison between urban and rural hospital practices

There is a need to identify the educational needs of general practitioners working not only in urban practices but also in rural practices. Similar studies have been performed in Australia[64] to identify the educational needs of so-called country doctors. Significant differences were found regarding the amount of procedural work that was undertaken by country doctors compared to metropolitan doctors.

For rural doctors, the findings of this study provide an affirmation of their wide range of clinical practice particularly concerning the performance of procedures. It is generally excepted that rural general practitioners have to perform more procedures than their urban counterparts [64,79].

- **Oro/nasotracheal intubation (Table 30)**

No statistically significant difference was found regarding the incidence of performance of oro/nasotracheal intubation between rural and urban practices, although the procedure is more frequently performed per year in rural hospital practices ($p=0.015$). No significant difference was found regarding the rating of essentiality, comfortability, difficulties and complications. Rural doctors however rated the influence of clinical anatomy on reduction of difficulties and complications ($p=0.001$) as well as the increase in confidence ($p=0.0236$), as significantly higher.

This may be explained by the fact that rural doctors perform the procedure more often per annum, possibly due to the fact that general anesthesia is usually performed by them. They therefore have a greater sensitivity for difficult intubations, which can be identified by careful anatomical assessment prior to intubation. It is however not surprising that doctors from both practice situations regard the procedure as essential, given the demand on emergency care provision by general practitioners in both practice situations.

- **Cricothyroidotomy (Table 30)**

A significantly higher incidence (p=0.026) and frequency rate (p=0.0001) was found amongst doctors in urban hospital practices compared to rural practices. This may be due to the fact that general practitioners are responsible for the emergency room in all the urban hospitals included in the study as well as the higher incidence of trauma draining to these centers for instance motor vehicle accidents.

The fact that urban doctors have more difficulties with the procedure (p=0.0013) can be explained by the fact that they perform the procedure significantly more often and are therefore more alert to difficulties that may occur.

Both groups have an equal assessment of the essentiality of the procedure, complications as well as the assessment of the influence of clinical anatomy on reducing difficulties and complications and increasing confidence to perform the procedure.

- **Vascular access via the great saphenous vein (Table 30)**

There was no significant difference on the incidence of the performance of great saphenous vein cannulation between the urban and rural doctors group (p=0.51), however urban doctors perform the procedure more often per year than the rural doctors do (p=0.04). Although the significance is not strong, urban doctors may have been more exposed to the value of this procedure than their rural counterparts due to the fact that they are closer to tertiary academic institutions.

This with the fact that the performance of this procedure heavily depends on the position and relations of the great saphenous vein, may also explain why significantly more rural doctors regard the influence of clinical anatomy on reducing difficulties and complications (p=0.006) and increasing confidence to perform the procedure (p=0.003) as important. An educational challenge therefore exists in rural hospital practices regarding this procedure.

- **Lumbar puncture (Table 30)**

A great significant difference is seen regarding the incidence (p=0.0002) and essentiality (p=0.0001) of the performance of lumbar puncture in rural and urban hospital practices. Significantly more rural doctors perform the procedure and regard the procedure as essential. This may be explained by the fact that rural doctors are much more so than their urban counterparts required to perform spinal anesthesia for various surgical procedures (like cesarean section) as well as lumbar punctures on pediatric patients due to the absence of full time pediatricians in rural hospital practices.

Significantly more doctors regard the influence of clinical anatomy in reducing difficulties and complications (p=0.01) as important. This may be explained by the possible greater awareness or rural doctors of difficulties and complications which are anatomically related, because their performance rate of the procedure is higher.

- **Pericardiocentesis (Table 30)**

There was no significant difference on the incidence of the performance of pericardiocentesis between the urban and rural doctors (p=0.367), however urban doctors perform the procedure more frequently per year than their rural counterparts (p=0.028). Although the significance is not very strong, this may be explained by the fact that priority one trauma cases are more commonly seen in urban hospital practices and the fact that cardiothoracic surgical expertise is present in most urban hospitals which form an important backup for this procedure.

Both rural and urban doctors regard the procedure as essential and there was no statistically significant difference between difficulties (p=0.632) and complications (p=0.074) experienced by rural and urban doctors.

Rural doctors regarded the influence of anatomy to reduce difficulties and complications (p=0.012) and to increase confidence to perform the procedure (p=0.027) as more important than the urban doctors, possibly due to less expertise around them.

- **Subclavian vein catheterization (Table 30)**

Significantly more urban doctors not only perform (p=0.002) but also more frequently perform (p=0.0002) subclavian vein catheterization compared to doctors in rural hospitals. This may be due to the availability of radiological expertise in urban hospitals compared to rural hospitals where radiological services are often only available for a limited time during the day. After performing a subclavian vein catheterization, a chest X-ray needs to be done to rule out the possibility of a pneumothorax. Another reason might be the availability of doctors to supervise the procedure in urban hospitals as well as the access to postgraduate training programs in urban hospitals.

For the same reasons, rural doctors are significantly more uncomfortable (p=0.0005) compared to the urban doctors group. It also explains why rural doctors regard the influence of clinical anatomy to reduce difficulties and complications (p=0.0066) and to increase confidence in the performance of the procedure (p=0.005) as significantly more important.

Both doctors equally thought that the performance of the procedure is essential.

Urban doctors experience significantly more difficulties (p=0.004) and complications (p=0.0008) compared to rural doctors, most likely because they perform the procedure significantly more often.

- **Internal jugular vein catheterization (Table 30)**

No significant difference was found regarding the incidence of performance of internal jugular vein catheterization between urban and rural doctors (p=0.082). Urban doctors do however perform the procedure significantly more frequently per year (p=0.004).

Urban doctors regard themselves as more uncomfortable with the procedure (p=0.002) and experience significantly more difficulties (p=0.0001) and complications (p=0.0009) than rural doctors.

This route of internal jugular venous catheterization seems to be more widely practiced in rural hospitals, rather than the subclavian vein route. This is not surprising for it is well documented that complications are generally lower when the internal jugular vein access route is used[80].

Rural doctors regarded the influence of clinical anatomy to increase confidence to perform this procedure as significantly more important (p=0.035).

- **Cesarean section (Table 30)**

Significantly more rural doctors perform cesarean sections (p=0.0001) and also regard the procedure as significantly more essential in their practice situation (p=0.0001). This is not surprising as rural general practitioners are usually running obstetric services in rural hospitals in South Africa and therefore need to be competent to perform this procedure.

Rural doctors experience significantly more complications (p=0.0009), most likely due to the fact that their performance rate is much higher.

Both doctors groups regard the influence of anatomy to reduce difficulties and complications and increase confidence of performance as very important, which is understandable due to the invasive nature of this surgical procedure.

- **Reduction of uncomplicated forearm fractures (Table 30)**

Rural doctors have a significantly higher performance rate (p=0.0001) concerning the reduction of uncomplicated forearm fractures and regard the procedure as significantly more essential (p=0.0001) in their practice situation.

Due to this fact, one would expect them to experience significantly more complications, which is indeed the case (p=0.045).

These differences as well as the importance of anatomy and biomechanics on correct reduction of forearm fractures, explains why rural doctors regard the influence of clinical anatomy relevant to this specific procedure to reduce difficulties and complications as significantly more important (p=0.022).

- **Ectopic pregnancy surgery (Table 30)**

Due to the fact that general practitioners in rural hospitals in South Africa run the obstetric services as well as the emergency surgical theatre, especially after hours, it is not surprising that the performance rate (p=0.0002) as well as the frequency rate per annum (p=0.034) of ectopic pregnancy surgery is significantly higher for rural general

practitioners.

Due to the necessity to perform this procedure in rural hospitals, it is no surprise that rural doctors regard this procedure as significantly more essential in their practice situation (p=0.0001). Ectopic pregnancy surgery is usually performed by the Obstetrics and Gynecology department in urban hospitals.

- **Appendectomy (Table 30)**

There was no significant difference observed regarding the performance rate of appendectomy between rural and urban general practitioners (p=0.855). This may be explained by the fact that the urban doctors were older and more experienced and the rural doctors younger and less experienced. Rural doctors do however regard the procedure as significantly more essential (p=0.0001). This is a very strong significance which reveals the demand on rural doctors to be able to perform the procedure.

The influence of anatomy on reducing difficulties and complications, is regarded as significantly more important by rural doctors (p=0.017). This with the equal performance rate between urban and rural general practitioners may be explained by the fact that urban general practitioners usually have greater access to supervised instruction of the procedures by a member of the Surgery Department. Rural doctors with limited supervised opportunities have therefore a greater sense of dependence on their anatomical foundation underlying this invasive procedure.

- **Wrist and digital nerve block (Table 30)**

Both urban and rural general practitioners reported a high performance rate on wrist and digital nerve block, although significantly more rural doctors regard the procedure as essential (p=0.021) in their practice situation. This may be due to the fact that access to general anesthesia is more limited in rural hospitals and the role of regional anesthetic techniques is therefore of great importance.

Both groups regard the influence of anatomy on reducing difficulties and complications and to increase confidence of performance as equally important. This is encouraging for the reliance on the exact anatomy of the nerves in relation to the wrist and digits is very important.

- **Knee joint aspiration (Table 30)**

Significantly more rural general practitioners perform knee joint aspirations (p=0.006) and they also regard the procedure as significantly more essential in their practice situation (p=0.0001). This may be explained by the fact that due to the availability of orthopedic services in urban hospitals, urban general practitioners are less likely to perform knee joint aspirations.

Due to the higher performance rate of this procedure in rural hospitals and the fact that several anatomical key points are crucial for successful performance, it is not surprising that rural general practitioners regard the importance of anatomy on reducing difficulties and complications as significantly more important (p=0.023).

- **Epistaxis and nasal packing (Table 30)**

No significant difference was found regarding the management of epistaxis and nasal packing between urban and rural general practitioners regarding all aspects investigated. This is not surprising due to the very common nature of epistaxis in both practice situations, which has traditionally been the responsibility of the family physician to manage.

- **Rectal examination (Table 30)**

No significant difference was observed regarding the performance rate (p=0.796) and the essentiality grading (p=0.560) of rectal examination between rural and urban general practitioners. This does reflect the importance of this procedure in both practice situations.
Rural doctors did however regard the influence of anatomy on reducing difficulties and complications (p=0.013) and on increasing confidence to perform the procedure (p=0.027) as significantly more important.

The following is clear from the comparison of all 15 selected problem procedures regarding several aspects of competence as perceived by urban and rural doctors:

a) The central role of clinical anatomy in the reduction of difficulties and complications. This role is recognized to be significantly higher by rural general practitioners in the following procedure in order of strength of significance: oro/nasotracheal intubation (p=0.001), great saphenous vein cannulation (p=0.006), subclavian vein catheterization (p=0.0066), lumbar puncture (p=0.010), pericardiocentesis (p=0.012), rectal examination (p=0.013), appendectomy (p=0.017), reduction of uncomplicated forearm fractures (p=0.022) and knee joint aspiration (p=0.023).

   No urban doctors regarded the influence of anatomy to reduce difficulties and complications for any procedure as more important compared to rural doctors. It is therefore of crucial importance to conduct training programs in the relevant anatomy necessary to perform these procedures safely especially in rural hospital practices.

b) Rural general practitioners regard the following procedures to be significantly more essential in their practice situation compared to urban general practitioners in order of strength of significance: knee joint aspiration (p=0.0001), appendectomy (p=0.0001), ectopic pregnancy surgery (p=0.0001), cesarean

section (p=0.0001), reduction of uncomplicated forearm fractures (p=0.0001), lumbar puncture (p=0.0001), internal jugular vein catheterization (p=0.0008) and wrist and digital nerve block (p=0.021).

No procedures were regarded as significantly more essential in urban practices. This is of great importance and illustrates the crucial challenge of addressing the unique demands and needs of rural general practitioners, concerning the above mentioned procedures. More work needs to be done regarding the continued medical education of the procedures in rural hospitals. This notion is underscored by rural family practice in Canada. Hamilton[79] states that rural general practitioners need more academic knowledge and skills than their urban colleagues. There is a tendency to train residents in postgraduate Family Medicine programs for urban practice only[79].

Practicing as a family physician in a rural hospital practice may draw one out of an area of expertise into diverse procedural challenges[11].
Wigton[41] reports that internists practicing in smaller hospitals and communities perform more procedures. This is in line with the results presented in this study for general practitioners in rural hospital practice. In this practice setting, physicians may have to depend solely on their own skills in performing procedures that might be referred elsewhere. Another complicating factor is that the resources for performance of the procedure may be unavailable.

c) A significantly higher performance rate or frequency of performance per annum was reported by rural general practitioners for the following procedures (in order of strength of significance): cesarean section (p=0.0001), reduction of uncomplicated forearm fractures (p=0.0001), ectopic pregnancy surgery (p=0.0002), lumbar puncture (p=0.0002), knee joint aspiration (p=0.006) and oro/nasotracheal intubation (p=0.015).

A significantly higher performance rate or frequency of performance per annum was reported by urban general practitioners for the following procedures (in order of strength of significance): cricothyroidotomy (p=0.0001), subclavian vein catheterization (p=0.0002), internal jugular vein catheterization (p=0.004), pericardiocentesis (p=0.028) and great saphenous vein cannulation (p=0.044).

d) It seems that generally the performance rate of most emergency procedures are higher by urban general practitioners and that the performance rate of most surgical procedures generally have a higher performance rate amongst rural general practitioners.

One should however be careful to make deductions regarding the educational needs of both these practice situations for although the performance rate is for example higher, the continued medical educational needs may not subsequently be lower and vice versa. This notion is underscored by Wigton[30] when saying that performance rate and training needs are not indirectly related.

e) Being younger, male and practicing in rural hospital practice reflects the performance of a greater number of procedures (Table 5). This correlates well with a study done by Eliason[81] in the USA. Young doctors may not be as experienced as older doctors, but due to the hospital practice profile where thay work, a high demand is laid upon them to perform procedures.

5.4 Development of a clinical anatomy knowledge base for each selected problem procedure

According to the key features approach as described by Page *et al* [52], there are unique key features to every clinical problem. This model can be translated to procedural skills training and assessment regarding the role of clinical anatomy in the safe and successful performance of procedures.
For all the selected procedures, clinical anatomical key features unique to the procedure were developed. This was done by studying the literature extensively of both the basic and clinical sciences regarding the key clinical anatomical features of the selected procedures and was further enriched by personal communication with content experts in the field of clinical anatomy and procedural skills training[i].

5.5 Development of a clinical anatomy training program

Developing and teaching an educational program, involves several key elements as defined by Kennedy[82]: i) it should effectively communicate content, ii) it should coach for skills improvement and iii) it should be a thoughtful guide to analytical thought. Due to the various duties of tertiary education institutions of which the responsibility to students is the core of its mission, emphasis should not only be on research, but also on the core business of educational innovation[82]. This also involves the duty of continued educational programs in the community, and *for* the community.

Creating medical educational programs which contribute to patient care by improving the

[i] The following content experts are named:
Prof PH Abrahams, Kigezi International School of Medicine, Girton College, Cambridge, UK
Prof JH Meiring, Department of Anatomy, University of Pretoria, South Africa
Mr T Welsh, Queens College, Cambridge, UK
Dr IG Parkin, Department of Anatomy, Univeristy of Cambridge, UK
Mr RH Whitaker, Department of Anatomy, University of Cambridge, UK
Mr B Logan, Department of Anatomy, University of Cambridge, UK
Prof T Olson, Albert Einstein School of Medicine, New York, USA
Dr Helen Bloch, Long Island Jewish Medical Centre, New York, USA
Dr W Rennie, Long Island Jewish Medical Centre, New York, USA
Dr R Kneebone, St Mary's Hospital, London and Bath University, UK
Dr T Silver, St Georges Hospital Medical School, London, UK
Mr V Mahadevan, Royal College of Surgeons of England, London, UK
Prof J Kauer, Katholieke Universiteit Nijmegen, The Netherlands

proficiency of practitioners in their community is a responsibility at the core of any medical faculty.

This study focuses on an important element of proficiency regarding procedures done in hospital practices in South Africa. The anatomy underlying this competency is often neglected and this fact has been linked to the increased incidence of complications and difficulties [7,9,11].

There is therefore a need to develop clinical anatomy programs, which presents the anatomy in relevant clinical context. Anatomy courses which are grossly overcrowded with factual information not relevant to the clinical world inhibits students from developing creative critical thinking The application of anatomical principles to procedural skills will strengthen the student's motivation for learning anatomy. Cahill *et al* [83] stressed the link between a basic science such as anatomy to clinical performance and introduced the concept of anatomic incompetence where the link is failed to be acknowledged. Teichgräber *et al* [84] has well illustrated the recognition of students regarding the importance of anatomy for diagnostic and therapeutic procedures.

Beahrs *et al* [9], a noted American surgeon pointed out that the surgical resident learns anatomy at the operating table. There is great truth in this notion, however it is often impossible to have supervision available during the performance of all surgical procedures. This is certainly true for developing countries. It is therefore necessary to study innovative solutions in procedural training.

With modern information technology it is now possible to create a virtual procedures clinic to teach clinical anatomy as an adjunct to the formal procedural training programs in various residencies. Within the clinical context of the procedures, anatomical pitfalls and complications can be demonstrated in an interactive way. In this way the principle of Bearhs *et al* [9], namely teaching at the operating table, can be practiced by way of simulation.
The nature of clinical procedures training, is that often there is no time to explain slowly and methodically how procedures are performed. A patient with an acute upper airway obstruction, cannot wait for a methodical teaching session, but needs a cricothyroidotomy immediately.

Teaching models[38] are therefore often an excellent substitute for teaching procedures. These models include animal models, plastic models, volunteers and cadavers for selected procedures[85]. The key question in assessing procedural skills is whether the skills learned on a model or prosection can be transferred to real patients[31].

Animal models are currently less used due to ethical issues regarding animal usage in research and teaching[38]. Also, the anatomy is different and these models are therefore not useful to focus on clinical anatomy competency regarding a procedure performed on patients .

Plastic models are ideal for teaching certain procedures where the focus is on teaching a

certain algorithm like in CPR (cardiopulmonary resuscitation) or where specific skills are taught. Plastic models however never reflect the true human anatomy where specific detail of relationships of structures are of great importance for safe and successful performance of the procedure. A good example of this is a model which is used for learning how to introduce a central venous catheter via the subclavian vein. Injury to the brachial plexus, subclavian artery or phrenic nerve cannot be demonstrated at all with this model. It has therefore serious limitations.

Using volunteers is often difficult if not impossible concerning the invasive nature of certain procedures. They are however of great value in the teaching of non-invasive examination procedures and skills.

Cadavers, whether fresh or preserved can be used with great success in the teaching of clinical procedures. Fresh cadavers however present the risk of transmission of infectious diseases like HIV or Hepatitis B and is not an option in the South African context. Embalmed cadavers, although less realistic, can still be successfully used as a teaching model of various clinical procedures.

Nelson[38] mentions the following procedures for which the cadaver is an excellent teaching model:

Airway management: Endotracheal intubation (oral and nasal), placement of naso- and oropharyngeal airways, cricothyroidotomy, chin lift and jaw-thrust maneuver.

Wound care: Suturing, local anesthesia, nerve blocks.

Chest procedures: Needle thoracostomy, thoracostomy, thoracotomy, pericardiocentesis (with a pericardial sac filled beforehand).

Abdominal procedures: Nasogastric tubes, peritoneal lavage.

Neurologic or neurosurgical procedures: Gardner-Wells tongs, burr holes.

Miscellaneous: Urinary catheter insertion, arthrocentesis, cut downs, nasal packs, nail removal.

Rennie *et al* [85] have used embalmed cadavers in an extensive training program on the clinical anatomy of emergency procedures in New York. The following procedures appear in their practical anatomy course, which has been conducted with great success over the past 10 years in New York[86]:

Hand: wrist block, digital nerve block, drainage of paronychia and felon, extensor tendon repair.
Forearm: fasciotomy.
Neck: subclavian and internal jugular central venous lines.
Airway: cricothyroidotomy (needle and surgical).

Face: supraorbital, infraorbital and mental nerve blocks, anesthesia for ear lacerations.
Neurosurgery: burr holes, cervical tongs.
Shoulder: shoulder relocation techniques, radiographic interpretation, arthrocentesis.
Arm and elbow: relocation techniques, radiographic interpretation, arthrocentesis.
Knee: maneuvers for knee examination, radiographic interpretation, arthrocentesis.
Ankle: radiographic interpretation, posterior tibial and sural nerve blocks, arthrocentesis.
Vascular: venous cutdowns at cephalic, basilic and great saphenous veins.
Chest: needle thoracocentesis, chest tube placement, pericardiocentesis, open thoracotomy, cross clamping of the aorta, repair of a cardiac lesion.
Abdomen: diagnostic peritoneal lavage.

Nelson[38] mentions a few procedures that do not work well to perform on cadavers, eg: central venous lines, lumbar puncture, ophthalmologic procedures, arterial blood gas sampling and the insertion of peripheral intravenous lines. Although they may be difficult to perform on a cadaver, these procedures may well be simulated on the cadaver or prosected specimen with or without the aid of computer technology in order to teach the clinical anatomy background of the procedure. There are limitations on how many times a procedure can be performed on a cadaver. However, for simulating a procedure on a prosected regional dissection by means of information technology does not have this limitation.

Using cadavers and specifically prosections to teach the clinical anatomy background of procedures is ideal. Focussed regional prosections relevant to the specific procedure were used in this study to demonstrate the clinical anatomy pitfalls and complications by means of multimedia computer technology. There are several advantages to simulated procedural training by means of regional dissections and computer technology:

i) It is always available and teaching can therefore be better structured and is less opportunistic.
ii) Repetitive teaching and interactive self-learning as well as self-pacing is possible, which is not possible on real patients.
iii) Staff and students can discuss problems freely.
iv) Anxiety during performance is reduced.

Simulated situations form an important part of medical education programs. One of its important benefits is their value in allowing practice of difficult, painful or embarrassing procedures[87]. This ensures that doctors do not need to perform a procedure for the first time in the middle of the night without supervision and on a desperately ill patient[91].

5.5.1 The use of computer technology in procedural skills training (Virtual Procedures Clinic)

Different opinions are expressed in the literature concerning the influence of instructional media on the learning process. Clark[89] argues that instructional media are merely vehicles used to deliver instruction and do not affect the learning process. Cobb[90] on the other hand argues that different media have an impact on cognitive learning but do not necessarily produce different learning outcomes. Jonassen[91] suggested that media and

technologies are not merely a vehicle of content delivery, but are part of the context. Teachers therefore need to consider the instructional design, learning environment and context in delivery systems. Maddux *et al* [92] points out that high interactivity is the most important factor which differentiates computers from other educational delivery modes.

Information and communication technology offers universities the opportunity to develop effective flexible learning environments. The barriers of distance and time are being broken down by new opportunities for optimizing interaction[13]. This is true for postgraduate and undergraduate students. Boon *et al* [13] has shown that a CD-ROM can effectively be used by general practitioners in a postgraduate anatomy course in South Africa, and Levine *et al* [93] has demonstrated the efficient and flexible way in which educational technology can be utilized in undergraduate teaching in the dissection laboratory.

Tavares *et al* [94] has also shown in a study where computer based sessions were used for the teaching of radiological anatomy, that students strongly approve the use of instructional tools in the educational process. It is therefore important to translate this concept of computer-assisted environments to the teaching of procedural skills. Wigton[30] points out that training of the cognitive aspects of procedural skills lends itself to training through self-contained educational programs such as computer based education. Computers can be used to assist the learning of both knowledge and skills of clinical procedures.

Anatomy is one of the biomedical disciplines that has benefited most from development in computer technology, mainly due to visualization and representation of knowledge[95]. The integration of resources on a CD-ROM platform can advance well beyond the limitations of a book. Learning is not only dependent on the didactic skills of a program or teacher, but also on the environment where learning takes place. The closer the learning environment comes to the environment where the knowledge base is applied, the better. Ideally both environments should be the same. This is however not always possible. According to Daetwyler[96], computer based learning environments can serve as a good platform to introduce the knowledge base to a virtual clinical environment. This principle is introduced into the virtual procedures clinic. I believe that the computer can effectively mediate the knowledge base of a procedure.

Computerized simulations on prosected anatomical dissections to illustrate the clinical anatomy pitfalls and complications, followed by actual performance of the procedure on the cadaver, seems to be a very effective teaching methodology. Kneebone[31] described a five-stage approach to learn a surgical procedure using a multimedia CD-ROM in combination with simulated tissue as an educational framework. These stages include (1) watching of an animated graphic, (2) watching a clinical video-clip, (3) watching a demonstration on a simulated tissue model, (4) performing the procedure on a model and (5) performing the procedure on a patient under supervision.

During the present study Kneebone's[31] approach was modified to the following relevant to clinical anatomy training of procedures by using a CD-ROM platform: (1) Studying

the clinical background (cognitive framework) to the procedure which involves indications, contraindications, a step by step outline and materials needed for the procedure, (2) studying the anatomical pitfalls and complications on animated prosections, (3) watching a simulated procedure on a prosection and (4) performing the procedure on a prosection.

There are several reasons for the choice of a CD-ROM as platform in our situation[13]. Firstly, CD-ROM is characterized by a large storage capacity for interactive media. It therefore overcomes the problem of low bandwidth currently experienced in South Africa in online course delivery. For example, images, video and animated graphics need much more bandwidth capacity than text. Secondly, CD-ROM can offer simultaneous combinations of different media formats such as text, images, graphics, sound, video and animation, with hyperlinks between them. Thirdly, general practitioners are not solely dependant on online environments and can study the content at their own work stations by using CD-ROM. Fourthly, general practitioners can access the Virtual Procedures Room in a flexible non-linear way according to their specific needs.

The CD-ROM's developed by Primal Pictures [97,98,99] are an excellent example of how high quality media can be presented in an interactive way complementing each other as an educational package. Their programs are also available via a www patform[100]. Treadwill *et al* [101] has also developed CD-ROM courseware along the lines of integrating various resources on different skills in an educational program. Alexander[102] has developed a radiology survival manual (webtextbook) which integrates text, radiological and superimposed anatomical images as well as patient case studies. It is created as a syllabus for a course and serves as a worldwide resource as it is freely accessible via the www. Gordon *et al* [103] has showed the efficacy of teaching procedures with a combination of computerized multimedia programs with simulations. Kneebone[31] stresses the point that any simulation in medical practice is a prelude to real patient performance. Abrahams *et al* [97,104] argues that computer learning reinforces the clinical understanding of the human body. This can be done by the interactive use of CD-ROM in an integrative course assisted with the use of the www and multimedia demonstrations. Abrahams *et al* [97] has developed a CD-ROM on interactive clinical anatomy and has illustrated how various media like cadaver prosections, cross sectional anatomy, skeletal anatomy, radiographic anatomy, histology and clinical correlations are interlinked with relevant text, video and audio clips, that covers the topics recommended by the Clinical Anatomy Curriculum for the 21st century by the American Association of Clinical Anatomists[105]. These resources are accessible in a non-linear way by means of seamless navigation and a search facility across resources.

The Virtual Procedures Clinic was developed with the same philosophy of easy access to relevant information linked to various resources regarding clinical procedures. **The Virtual Procedures Clinic that was developed is attached as a CD-ROM**. The teaching program assumes a set of basic surgical skills to perform a procedure. For conduction of the workshop, it is suggested to place the computer close to the prosections on which the procedure is to be performed, with the necessary instruments for every procedure. The multimedia program serves as the knowledge base and the simulation of

the procedure on the prosection as the skills base. The student can then compare the performance of the procedure on the prosection with the simulated procedure on the screen.
The CD-ROM allows access to a wealth of clinical background information as well as clinical anatomy information linked to animated prosection images. The CD-ROM allows for self-directed learning. Extensive hyperlinks allow for easy and non-linear navigation within the program.

A non-linear access has been developed to various rooms in a Virtual Procedures Clinic. This virtual clinic environment introduces the student to various rooms in a virtual clinic. The first impression in a learning program is often very important[96]. The first screen which maps out the virtual procedures clinic, communicates the "reality" of the environment in which the student is going to learn. A similar platform was used by Henderson *et al* [106] in his Primary Care of the HIV/AIDS patient: A Virtual Clinic.

The internet based Virtual Hospital of the University of Iowa Health Care in the USA[107], uses a similar platform. This Virtual Hospital allows access in a non-linear way to the following for both health care workers and patients: A welcome area to the Virtual Hospital, an environment for health care providers, for patients, a room where common problems are dealt with as well as an area beyond the Virtual Hospital. These topics are all hyperlinked to various resources by means of hypertext. These are examples environments providing functional access to medical information which is relevant to medical practice [108].

The same principle of a virtual environment has been used in the Virtual Procedure Clinic.

There is an increasing demand for instantly accessible information to aid general practitioners in the performance of procedures. This demand can be met by developing an electronic knowledge reference, which allows a non-linear way to access knowledge.

Several software packages can be used to accomplish this. PowerPoint® for example provides the possibility of hypertext links and hypermedia to facilitate instruction. General practitioners can therefore decide on their own route through the content by means of hypertext, linking a node of content, whether text , image, animation, audio or video to another node.

PowerPoint® was used in the development of the training program for the following reasons:

i) The program is widely available on standard computer software packages in South Africa.
ii) It allows for immediate use in a continued educational environment for both self-directed learning methods and lecture based teaching.
iii) It allows for user friendly programming by the simple creation and handling of text, images, animations, video, audio, hyperlinks and hypertext as well as a non-linear mode of access. Similar to what

Carmichael *et al* [109] has done concerning image processing, images are easy to import into PowerPoint® after which labeling and enhancement can be done.

iv) It allows for dynamic learning of clinical anatomy and not from a static slide, which is usually overwhelmed by information. With PowerPoint® a concept can be explained by starting with a simple image which sequentially grows in detail [109] with labeling and animations. This is done in an educationally sound way as relevant to the specific topic.

v) It allows to save the file in HTML format after which it can be uploaded to a website.

The rooms in the Virtual Procedure Clinic include and orientation room, library, clinical anatomy laboratory, clinical background room and simulation room. The goal of this virtual environment was to use computer-based technology to overcome a number of obstacles in the teaching process and to integrate resources that are usually not found in one environment. The program is based on the so-called constructivist school of thought in medical education, where a student is immersed in a multimedia environment where he/she can construct their own knowledge from a variety of options [91].

Simulation Room

The goal of this room is not to provide an exact simulation of the procedure, but to simulate key important points from an anatomical perspective by using computer technology and real dissections. The simulations are done in a step by step approach assisted by text, images, audio clips and animations. A similar methodical approach is followed by Kneebone[110], pioneer of national training courses in minor surgery in the UK, in his gold standard CD-ROM on teaching surgical skills relevant to minor surgical procedures.

Chapman[60] has showed that computer simulation using complex visual anatomical images and sequential ordering of procedural steps show promise for teaching and assessing skills which are fundamental for procedural competency.

Clinical Anatomy Laboratory

Wherever possible a key anatomical pitfall or complication was illustrated on one page in the PowerPoint® environment, which is accessible in a non-linear way.
High resolution images of prosections where selected to match the anatomical pitfalls and complications of the specific procedure. The images were carefully annotated by means of the functions in PowerPoint®. Similar work to annotate images in a digital way was done by Hejle[111] in Denmark on prosected material as well as by Abrahams[97] in the UK.

Further ideas regarding the lay-out and organization of the images was obtained from the program Anatomy Revealed [112], an award winning integrative multimedia CD-ROM program.

Audio clips were used to illustrate key points regarding anatomical pitfalls and complications. This ensures that relevant information is available to assist a graphic animation of a key point illustrated on a prosection in a way as if the professor is giving advice and comments over the shoulder of the operator. Daetwyler [113] has used audio and video clips successfully in this way in his program Headache Interaktiv, where background information is given by a content expert.

Clinical Background Room

Wigton [68] stressed the importance of a sound background knowledge base for safe performance of procedures. We have developed this room along these lines by including information on indications, contra-indications, materials necessary and a step by step approach to perform the procedure. The CD-ROM's developed by Wigton [114,115] are all based on a sound clinical background knowledge base which are presented by various media on a CD-ROM platform with internet linkage for updates.

Animations

Various animations were created to illustrate the position of for example the needle in a specific procedure or to illustrate a specific complication linked to a particular anatomical concept. Animations make an illustration dynamic or put the illustration into motion and can easily be used to illustrate clinical procedures. Several principles govern the use of animations as discussed by Guttman [116]. One of these is timing. It is important that the user can follow the animation and not loose interest because it moves too fast or too slow. We used the 'crawl' function in PowerPoint® to accomplish this. Another principle is anticipation where a device is created to catch the attention of the user before the action takes place. This was done by introducing an interactive icon stating what is to follow by clicking on it.

Animations in the Virtual Procedure Clinic were done in PowerPoint®, but more sophisticated animated movies require more advanced digital movie-making programs such as Macromedia Flash®.

Uses

The CD-ROM can be used in several environments. First, the busy family physician performing various procedures requires immediate access to information on pitfalls and complications and therefore use the program in his practice from his/her own desk computer station. The program can also be used for patient explanation of a proposed procedure. Secondly, the CD-ROM provides a learning tool for continued medical education on clinical procedures either individually or in small groups like a journal club in a hospital or group practice. Thirdly, the CD-ROM can be ideally used for training purposes, not only at academic institutions during residency or undergraduate medical courses, but also by hospital practices for the training of current and new intake doctors. Ideally the program should be made available during residency training of general practitioners and for learning and review near patient care areas. It can be used for

undergraduate teaching illustrating basic clinical anatomical concepts.

5.6 Limitations of the study

There are some limitations to this study:

1. Although 3 provinces in South Africa were included in the study, the scenario for clinical procedures in other parts of South Africa may be somewhat different. This study may therefore have limited geographical generalizability. It is thought however, that the data presented reflect a general picture due to the representative number of general practitioners in hospital practice that took part in the study in Gauteng, Mpumalanga and the Northern province.

2. The study has a subjective element due to the fact that perceptions were measured. Conclusions are based on self report from the survey and not on actual objective observations. It is however regarded that perceptions are important and that essential data can flow from it. Subjective perceptions form an important part of the attitude, integrally part of procedural skills. Doctors filled out the questionnaire voluntarily and anonamously.

3. No cognitive assessment of knowledge of the procedures was used. Those procedures were identified which most general practitioners rated as essential, where most difficulties and complications were met and where clinical anatomy understanding was problematic.
   A next phase would be to conduct the training program that has been developed as well as cognitive assessment methods of clinical anatomy knowledge necessary for the procedure before and after the training program.

4. There may be inaccuracies on the data reflected by the survey. Terms like comfortable, difficulties and complications were not specifically defined. Some respondents may therefore have stricter or looser definitions than others.

5. A possible limitation may be the fact that an initial pilot study was not performed, which could possibly have lead to the inclusion of more procedures. Procedures that were added to the list by practitioners were done by individuals and were not by any means noted by the majority of practitioners. It is admitted that those procedures can be studied in a follow-up study, which is not considered to be part of this study.

6. Limitations exist in doing the survey. These include as mentioned earlier:
   a. The way that the hospitals were selected were not truly in a randomized way in the sense that each hospital had an equal chance to be selected and has an influence on the data. This should be seen in the light of the fact that an equal amount of responders were from both urban and rural hospital practices coming from three different provinces in South Africa. The aim was to obtain two groups of hospital practices where at least 40 different respondees could be obtained. The fact that every hospital did not

have an equal chance to be selected may be regarded as a drawback of the survey.

b. Some responders from the different hospital practices may have been absent on the day of the conduction of the survey or may have been busy in casualty or the operating theatre. This may have an influence on the data. The amount of responders where however more than 80% of general practitioners working in the specific hospital practices and where not previewed on the conduction of the survey. Everybody therefore had a fair chance to be included in the survey and it was attempted to include all general practitioners in the individual hospitals by conducting the survey on their weekly meeting.

c. Anonymity may be jeopardized by the fact that the researcher was present when the questionnaires were collected in a box, for they may have felt to be identified. There was therefore a slight theoretical chance for the researcher to identify a specific respondees completed questionnaire and therefore abridge anonymity, although the respondee was assured of staying anonymous due to above mentioned measures. The researcher however protected anonymity at all times and refrained from transgressing good ethical conduct.

5.7 Recommendations

1. General practitioners should be trained to perform competently those procedures relevant to their practice situation. This includes competency in clinical anatomy underlying the safe and successful performance of procedures. Regarding hospital practice, a core set of procedures should be included in residency programs. They should at least include those 15 procedures where difficulties and complications were highly rated. The remaining procedures could form an elective group of procedures which a resident might choose from to learn when the procedure is essential to his/her present or future practice situation.

2. Clinical anatomy programs for procedural competency should be included in all Family Practice residency programs in South Africa. These should at least include the 15 problem procedures that were identified in this study.

3. A log book for procedures performed should be kept in all hospital practices. Residents should note all procedures performed as well as difficulties and complications encountered. Periodic assessment of outcomes and complications can in this way be facilitated.

4. Training programs in Family Practice should ensure that their residents acquire sufficient clinical anatomy competency in each procedure included in the program.

5. This study provides data to help define standards for procedural training. It suggests that training in procedural skills in family practice residencies should be

reexamined. Standards need to be proposed for accreditation. Procedural training of general practitioners is not only a responsibility of specialists but lies primarily with Family Medicine[43]. It should not be assumed that because specialists usually take up this responsibility, there is no need to train general practitioners in procedural skills. This applies to both rural and urban hospital practices. The fact that the environment of family medicine training programs are often located in large urban hospitals with specialities, may provide false reassurance that general practitioners will not need procedural skills training.

6. Training of procedural skills are more important than ever. The current situation of inadequate procedural skills training programs is not acceptable. General practitioners completing the residency program need to be competent to perform the procedures relevant to their practice situation. This process actually already starts during undergraduate anatomy training.

7. We need more information on which procedures are taught in family practice residency programs as well as the competency of those completing the program.

8. We have developed a training program on a PowerPoint® platform, a widely available Microsoft package. Various more advanced modalities of simulation, video streaming and interactivity can be created in authoring environments like Macromedia. It is intended to continue this program by upgrading it in these environments. Modes of interactivity including the facility to assess clinical competence should be incorporated in the training program. These activities can be performed from a computerized platform as has been successfully done by Myers[117] in his web-based DxR Clinician program where a clinical competency exam is conducted to assess clinical reasoning skills.

9. Health care data such as is presented in this study needs to be recognized when policy decisions regarding funding and development of health care facilities are planned as well as educational design of undergraduate and postgraduate education.

10. A pre- and post course assessment is necessary to form an audit trial which is important for future refinements of the program.