SESSION VI: Joint Session of the AAVPT and the ACVCP on the Teaching of Clinical Pharmacology

Teaching an Elective Course and Rounds in Clinical Pharmacology

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I would like to thank the organizers of this symposium for inviting me to participate on a topic which is very near and dear to me: how do we effectively teach veterinary students about pharmacology and rational drug use, topics which constitute such an important part of the practice of veterinary medicine? In particular, this paper will focus on recent developments in the teaching of clinical pharmacology at Cornell University.

REQUIRED PHARMACOLOGY COURSES

In the 1991/1992 academic year, pharmacology instruction at Cornell consisted of required and elective courses. Required courses, which all veterinary students are obliged to take, were taught throughout the second year of the four year program. Pharmacology 528, taught in the first semester of the second year, was a 4 credit course, made up of three lectures and one "lab" session per week. The nature of this laboratory component has changed during the last ten years from predominantly live animal experiments to the current approach which consists of computer-based laboratories (e.g., demonstrations of pharmacokinetic principles; interactive videos in autonomic pharmacology) and discussions, for example, of pharmacy and prescription writing and extralabel drug use. Lecture topics in this course consist of three main areas: Introductory Pharmacology (drug absorption, distribution, metabolism and excretion, principles of pharmacokinetics and drug receptor phenomena); Neuropharmacology (approximately 20 lectures dealing with central nervous system, autonomic, neuromuscular and local anesthetic pharmacology) and the Pharmacology of Inflammation (histamine and antihistamines, prostaglandin and leukotriene pharmacology, nonsteroidal anti-inflammatory drugs).

Pharmacology 529, taught in the second semester of the second year, consists of two lectures per week and although different personnel are involved in teaching the course, it is essentially a continuation of the first course in pharmacology, dealing with topics not covered in the first semester e.g., Chemotherapy (13 lectures on antibacterial, antiparasitic,

antifungal, antiviral and anticancer drugs), Endocrine Pharmacology (thyroid, adrenocortical and insulin therapy) and aspects of Systemic Pharmacology not covered in Pharmacology 528 (e.g., cardiac, respiratory, urinary, gastrointestinal, ocular and dermatological pharmacology).

There are several concerns with teaching pharmacology in this manner. Under this system, students receive no formal instruction in pharmacology after the second year of the four year program. Since students have minimal opportunity to begin applying their knowledge of pharmacology until they are in the clinics in senior year, there is a long interval to ignore and forget what was learned in the required pharmacology courses. Furthermore, a better time to be taking pharmacology would seem to be at the time when medicine and surgery courses, where application of pharmacology is considered, are being given. While it might be argued that clinicians emphasize drug therapy in the medicine and surgery courses, experience indicates that this is usually a minor component of instruction. For example, while it might be mentioned that a certain antibiotic is ideal for a specific infection or that furosemide may be a good choice as a diuretic in a particular edematous state, the pharmacology of the drugs is not discussed, the rationale for that drug choice is not considered and points such as alternative drugs available may not be mentioned.

CLINICAL PHARMACOLOGY ELECTIVES

In response to concerns such as these, we initiated elective courses in clinical pharmacology at Cornell in the mid-1980's. These courses are currently offered in both semesters of the junior year as a way to keep our students thinking about drugs and pharmacology between the sophomore and senior year. The courses are offered during the time when required courses in medicine and surgery are presented.

At Cornell, elective courses are offered in addition to core or required courses. Students are required to complete a specific number of elective courses during the D.V.M. program, for the most part in the first three years of the curriculum. Our experience has been that the vast majority (over 90%) of each class take the elective courses in clinical pharmacology, indicating that students desire more information about this topic than that presented in formal courses, particularly if application of drugs is considered in a clinical setting. The courses are restricted to junior students,
after exposure to required pharmacology courses is completed. A number of students choose to take the courses during both the fall and spring semester.

Most recently, a small group approach has been used in these elective courses in clinical pharmacology. An optimum group size, in terms of generating discussion and group interaction, appears to be 8-10 students per group. Thus the courses are labour intensive; in a recent year, 60 students elected to take the course in the first semester and 40 in the second semester and therefore up to 6 one-hour sessions per week were devoted to meeting with the students. However, this approach seems more advantageous than a formal lecture format, which was used in earlier stages of development of the course, i.e., there is more opportunity for discussion to be generated and to achieve student participation.

The format of the course involves the use of cases in the teaching hospital to generate discussions in clinical pharmacology. An advantage at Cornell, which is not enjoyed by all

veterinary colleges, is the proximity of our hospital to the teaching facilities, allowing the students ready access to the clinics to study case material. The fundamental feature of the course is that students study case records of patients and focus on the drugs which have been utilized in treatment. The case records contain a great deal of information, not only on the chronological progression of the case but also ancillary information such as clinical pathology data, clinical microbiology results and anesthesia records. An added benefit of this approach is that it familiarizes students with the case records and, at least to a certain extent, prepares them for their senior year when they will be responsible for completing and monitoring the case records. We found that it was important, at the outset of these courses, to consult the clinicians and obtain permission to utilize their case material for discussion. Indeed, clinical faculty are enthused about the program because it gives the students early exposure to procedures in the teaching hospital.

At the outset (first several weeks) of the courses, in order to set the tone and establish protocol, the instructor takes the responsibility for choosing and presenting the cases. The optimum appears to be two cases per one hour session. Attempts are made to find a mixture of cases from the large and small animal clinics to represent various animal species. A particularly fruitful service to utilize is the Intensive Care Unit where animals are often being simultaneously treated with a variety of drugs from several drug classes. In this initial stage, it is especially important to inform the students which cases will be discussed in order for them to become familiar with the case and to observe the patient. In the latter portion of the course, onus is placed on the students (two per week) to choose and present case material. This approach stemmed from early course evaluations in which students indicated the desire for more responsibility in presenting the material in order to develop skills in analyzing case material and to experience some preparation for presenting their cases in rounds in the senior year.

Case discussions are initiated with a brief summary of the case, focusing on the history, progression of the illness and relevant diagnostic tests. However, emphasis is on the clinical pharmacology of the case and a detailed drug history as well as the drug(s) currently being utilized are considered in detail. In these discussions, several key points tend to recur (Table I).

Discussions of the clinical pharmacology of the cases generally begin with an identification of the drugs utilized as a means of familiarizing the students with the drugs as they are referred to in the clinics. Whereas our basic pharmacology courses tend to teach drugs on the basis of generic names, they are often referred to quite differently by clinicians and outside practitioners, e.g., by trade names or abbreviations (e.g., PPG for procaine penicillin G). The drugs are categorized in terms of the class and subclass they belong to and some fundamental information on their properties may be considered as a review of basic pharmacology courses. Students are encouraged to do some background reading about the drugs prior to the case discussion and this gives them the opportunity to refamiliarize themselves with handouts and notes received in the basic pharmacology courses. Other fruitful sources to consult for clinically-oriented drug information include Plumb's Veterinary Drug Handbook (Pharma Vet Publishing, White Bear Lake, MN) and compendia of current drugs such as Veterinary Pharmaceuticals and Biologicals (Veterinary Medicine Publishing Co., Lenexa, KS) for veterinary drugs and the Physician's Desk

Reference (Medical Economics Company, Inc., Montvale, NJ) for human-approved drugs. Occasionally, when an obscure drug is being utilized or when a key publication on a specific topic is available, articles may be copied and distributed to the students.

A large portion of the time is spent considering why a particular drug was chosen to treat the case. Since this focuses on the rationale for drug therapy, topics such as how the drug corrects the pathophysiology of the disease are considered in some detail. Commonly this discussion centres around the mechanism of action of the drug, often at the molecular level. Details about how the disease state may affect the action of the drug at the site of action are explored. Students are asked to consider how they would assess whether the drug is having a desired effect.

Attention is focused on alternative drugs that may have been chosen to treat the patient. Students tend to be presented with a biased view of drug choice based on personal preferences of the clinician. Could alternative drugs have been used and what were the reasons for the clinician's drug choice in our setting? Factors such as economics may come into play in this area. Again, it is emphasized that the clinician's drug choice is not being questioned - the point is that other options may have been available.

Consideration of the pharmacokinetic properties of the drugs is another opportunity to review information that was covered in the basic pharmacology courses. Students are asked to predict whether the drug will gain access to the site of activity (and what is the site of action?) and if the disease state may alter pharmacokinetics to the extent that dosage adjustment may be necessary. This topic is also an important point to emphasize species differences in pharmacokinetic parameters, e.g., what considerations would be important with chloramphenicol administration if the patient were a cat rather than a horse?

Toxic or adverse effects of the drugs are considered in some detail. Students determine whether any undesirable reactions have been induced by the drugs in the patient and, based on the drugs being utilized, what types of adverse effects they would be concerned about monitoring. Points are made about whether the disease state may make the patient more vulnerable to the development of adverse drug reactions.

A final point that is commonly discussed at some length is potential drug interactions. Cases that are particularly likely to be receiving multiple drugs simultaneously are those in the Intensive Care Unit, patients undergoing anesthetic/surgical procedures and certain ophthalmological cases. Discussions centre on the type of interactions which may occur and their consequences and on the mechanism of the interaction (e.g. pharmacokinetic or pharmaceutical interactions or interactions attributable to the disease entity).

Two cases which were recently discussed in our course may be cited as examples of our approach. Case #1 was a horse with a complicated fracture of the cannon bone. The fracture had been plated prior to coming to our hospital and infection had developed at the fracture site. The horse was referred to our clinic for replating and further treatment. The patient had been treated with antibacterial drugs prior to admission to our hospital and was continued on antibiotic therapy while in our clinic. Samples of discharge from the infected limb were submitted to the Diagnostic Laboratory and a reproduction of the culture-sensitivity data is shown in Table II. The data shown on this report served as a focal point for the discussion of the case and were used to illustrate number of points about antibacterial drug therapy.

Points were raised about the reliability and pitfalls of culture-sensitivity data, particularly with regard to the animals antibiotic therapy prior to acquisition of the sample. Culture results were discussed in light of the nature of the discharge from the infection site (odoriferous, serosanguinous). Attention was focused on the antibacterial drugs tested and the students were asked to identify and classify each of the drugs tested with some probing of their bactericidal versus bacteriostatic properties and mechanism of action. They were asked to consider why E. coli was susceptible to Timentin (ticarcillin/clavulanic acid combination) but not ticarcillin alone. Based on the culture-sensitivity data, the students were asked to suggest which antibacterial drug or combination of drugs they would choose and why. Unreliability of culture-sensitivity data, particularly with regard to the lack of information on pharmacokinetics of the drugs was discussed, which led to a consideration of the pharmacokinetic properties of the drugs to which the organisms were sensitive and which would be most likely to gain access to the site of infection in the affected limb. Finally, since this case was likely to require long-term therapy, students were asked to consider potential toxic effects of chronic drug use and the economics of treating a 1000 pound horse for an extended period.

The second case involved a 2-year-old Dalmatian that had a fractured tibia/fibula after being hit by a car. The referring veterinarian had performed surgery but was unsuccessful in repairing the fracture and the dog was sent to Cornell's hospital for surgical correction. The focus of attention in this case was the anesthetic record for the operative procedure (Figures 1 and 2), particularly the clinical pharmacology of the drugs used in the perioperative period.

Students were asked to identify the drugs which were given preanesthetically (acepromazine, glycopyrrolate, oxymorphone), to suggest why they were given and to consider such factors as whether there were any potential toxic interactions between the drugs (e.g., cardiovascular effects) and the time they were given in terms of the induction of general anesthesia. The drugs used to induce anesthesia (ketamine/diazepam) were identified and factors such as which of the various drugs are controlled substances and which have analgesic effects were considered.

A discussion of the chronology of the anesthetic and surgical procedures ensued, noting special points that pertained to clinical pharmacology. For example, it was noted that isoflurane was the inhalation anesthetic used and that the concentration of the drug was increased as the painful operative manipulations began at approximately 11:30. The administration of glycopyrrolate at 10:30 was discussed in terms of the mechanism whereby it induced an increase in heart rate in this patient with bradycardia. Note was made that cefazolin was given after the operative procedure had begun (at 11:50); students were asked to elaborate on the appropriateness of cephalosporins as prophylaxis for orthopedic procedures and why the administration of the drug was delayed until after the operation had proceeded in this case instead of being administered prior to surgery. Finally, the administration of oxymorphone at the end of the surgical procedure was used to engender discussion on the student's philosophy about narcotic analgesic use for pain control and how they would assess the need for the use of narcotic analgesics in animal patients.

In discussing case records, one must improvise as to the particular points discussed. Virtually any case in which drugs were used as part of the treatment protocol will contain

interesting information which can be used to demonstrate pharmacological principles. One can also speculate on interesting scenarios that may have occurred based on the drug history of the animal.

Certain difficulties have been encountered in developing a course of this nature. While it is important that students become familiar with the case and case record in order to optimally participate in class discussion, occasionally students do not have the opportunity to look at the material. A common problem is that the case is no longer in the hospital due, for example, to recovery. While not ideal, students may access the file from the Medical Records office or obtain limited information from the computerized record of the case.

Occasionally, the patient load in the clinic may be relatively light and students may perceive the lack of interesting material to present to the group. This has provided the opportunity to discuss interesting pharmacological topics which may not commonly be explored (e.g.? considerations of drugs which are toxic, on contact, to veterinarians and their clients; discussions of drugs which are potentially toxic to pregnant animals).

A final difficulty is that since an institutional teaching hospital is being used as the source of case material for clinical pharmacological discussions, more exotic and uncommon clinic~l presentations may tend to occur than are observed by the practitioner in the field. As a consequence, uncommon therapeutic regimes may tend to be emphasized more frequently than more conventionally used drugs.

I enthusiastically recommend teaching pharmacology using this format. It provides the students with drug information in a more interesting and "real world" context. Furthermore, a~ someone who has evolved through development of this type of course, it is extremely stimulating for a basic scientist to consider pharmacology from the viewpoint of the clinic floor as opposed to the laboratory bench or classroom.

Table I. Points of emphasis in clinical pharmacology elective.

1. Drug Identity
2. Reason for Drug Choice
3. Alternatives
4. Pharmacokinetic Considerations
5. Toxicity
6. Drug Interactions

Table II. Culture-sensitivity data from Case #1.

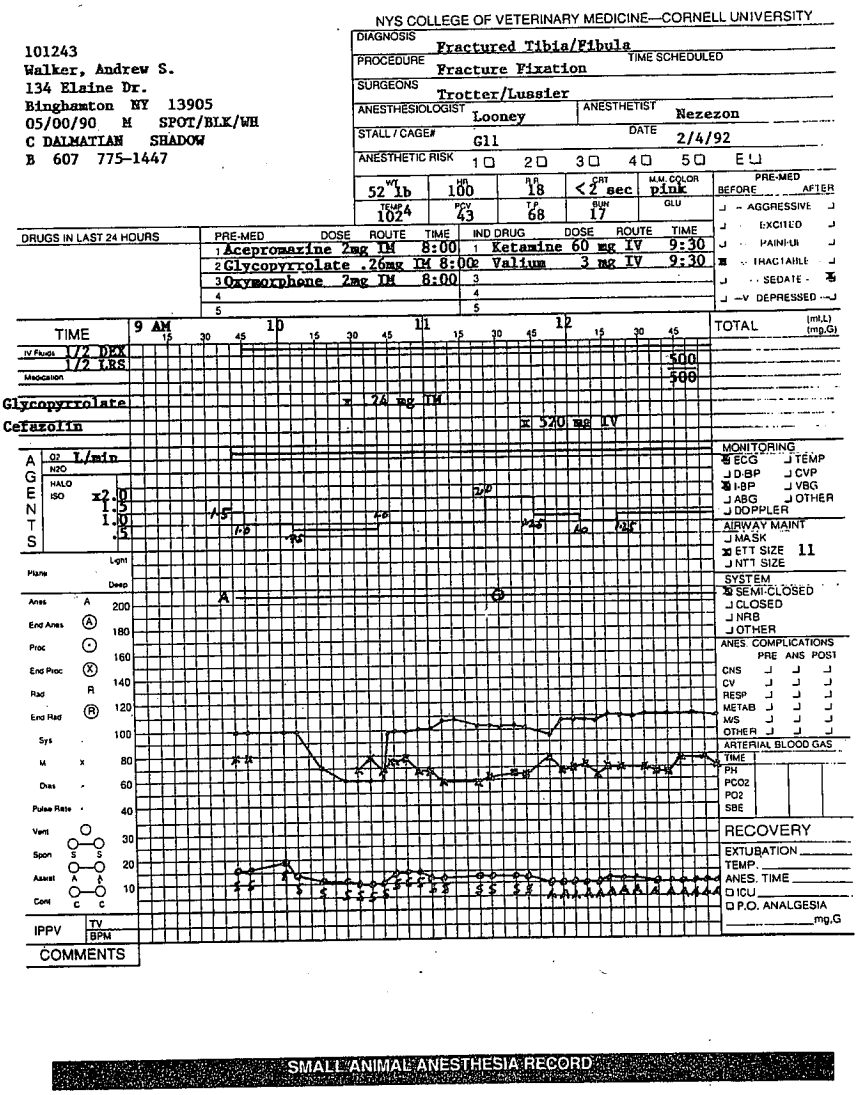
Specimen type: Location Unknown
Organism(s) tested: B402.99 - ESCHERICHIA COLI (MANUAL ENTERICS)
B906.99 - PSEUDOMONAS AERUGINOSA (MANUAL PSEUDOMONAS)
25 Sep 1991 00:36 Lab Results for LAC 840585
MIC results available in lab: Yes

	B402.99 Interpretation	B906.99 Interpretation
AMPICILLIN	Resistant	----------
TICARCILLIN	Resistant	Susceptible
TIMENTIN	Susceptible	Susceptible
AUGMENTIN	Susceptible	Resistant
CEFTIOFUR	Susceptible	Mod. Sensit
CEFTIZOXIME	Susceptible	Mod. Sensit
CEPHALOTHIN	Susceptible	Resistant
AMIKACIN	Susceptible	Susceptible
GENTAMICIN	Resistant	Susceptible
CIPROFLOXACIN	Susceptible	Susceptible
ENROFLOXACIN	Susceptible	Susceptible
CHLORAMPHENICOL	Resistant	Intermediate
TETRACYCLINE	Resistant	Intermediate
TRIBRISSIN	Resistant	Susceptible
TYLOSIN	Resistant	Resistant

TEST REQUESTED: Gram Stain
Date sample taken: 09/05/91
FINAL (See DL Accession #607401-1)
Specimen Type: Other tissue, location known
Result - MODERATE GRAM NEGATIVE RODS & MODERATE WHITE BLOOD CELLS

End of Diagnostic Lab Report for patient 840585 For the visit of Aug 25 '91.
End of Lab Results Report for Patient 840585, Visit of Aug 25 '91. ** This cumulative report supersedes all previous lab reports for this visit. Please discard all lab reports FOR THIS VISIT dated before 09/25/91.

Figure 1. Anesthesia record for Case #2.



NYS COLLEGE OF VETERINARY MEDICINE—CORNELL UNIVERSITY

101243
Walker, Andrew S.
134 Elaine Dr.
Binghamton NY 13905
05/00/90 M SPOT/BLK/WH
C DALMATIAN SHADOW
B 607 775-1447

DIAGNOSIS: Fractured Tibia/Fibula
PROCEDURE: Fracture Fixation — TIME SCHEDULED
SURGEONS: Trotter/Lussier
ANESTHESIOLOGIST: Looney — ANESTHETIST: Nezezon
STALL / CAGE#: G11 — DATE: 2/4/92
ANESTHETIC RISK: 1☐ 2☐ 3☐ 4☐ 5☐ E☐

WT	HR	RR	CRT	M.M. COLOR
52 lb	100	18	< 2 sec	pink

TEMP F	PCV	T.P.	BUN	GLU
102.4	43	68	17	

PRE-MED: BEFORE / AFTER — AGGRESSIVE, EXCITED, PAIN-UR, INTRACTABLE, SEDATE, DEPRESSED

DRUGS IN LAST 24 HOURS

PRE-MED	DOSE	ROUTE	TIME
1 Acepromazine	2mg	IM	8:00
2 Glycopyrrolate	.26mg	IM	8:00
3 Oxymorphone	2mg	IM	8:00
4			
5			

IND DRUG	DOSE	ROUTE	TIME
1 Ketamine	60 mg	IV	9:30
2 Valium	3 mg	IV	9:30
3			
4			
5			

TIME: 9 AM 15 30 45 10 15 30 45 11 15 30 45 12 15 30 45

IV Fluids: 1/2 DEX 1/2 LRS — 500 / 500

Medication: Glycopyrrolate x .26 mg IM; Cefazolin x 520 mg IV

AGENTS: O2 L/min; N2O; HALO; ISO x2.0 1.5 1.0 .5

Plane: Light / Deep

Anes A; End Anes A; Proc; End Proc X; Rad R; End Rad R; Sys; M x; Dias; Pulse Rate; Vent; Spon S S; Assist A A; Cont C C

IPPV TV BPM

COMMENTS

TOTAL (ml,L) (mg,G)

MONITORING: ECG, TEMP, D BP, CVP, I-BP, VBG, ABG, OTHER, DOPPLER

AIRWAY MAINT: MASK, ETT SIZE 11, NTT SIZE

SYSTEM: SEMI-CLOSED, CLOSED, NRB, OTHER

ANES. COMPLICATIONS: PRE ANS POST — CNS, CV, RESP, METAB, M/S, OTHER

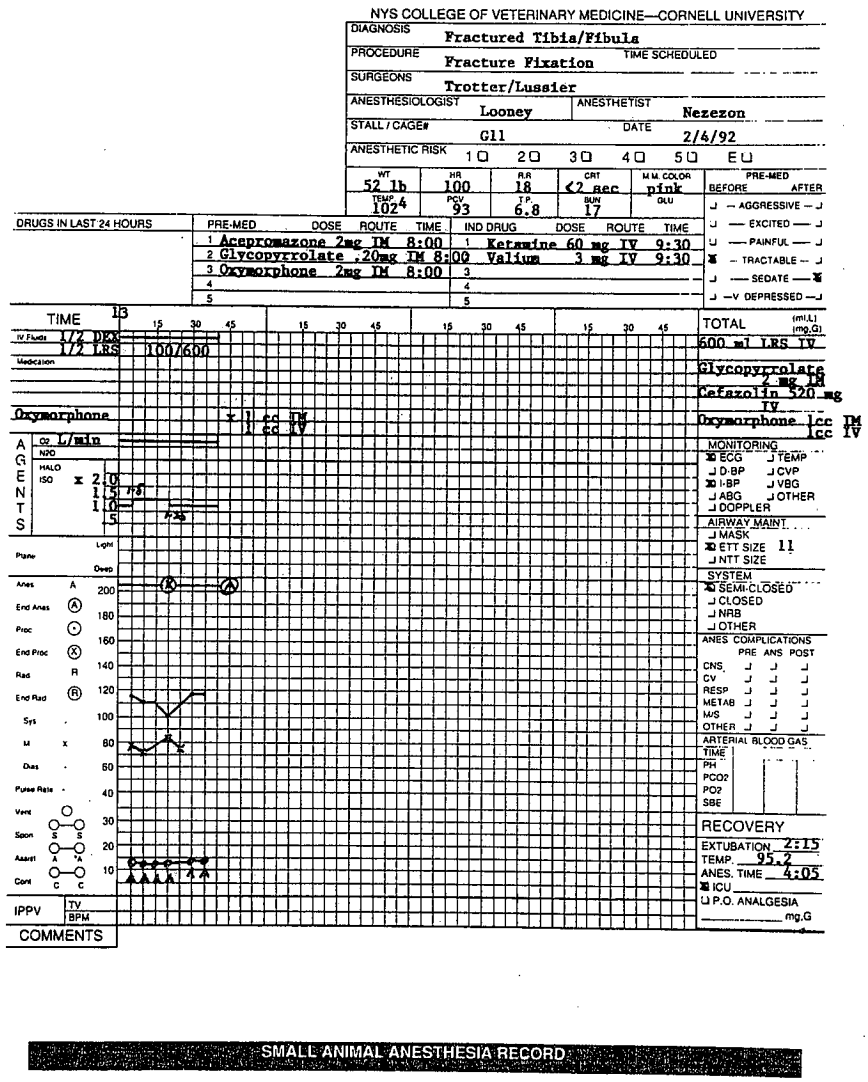
ARTERIAL BLOOD GAS: TIME; PH; PCO2; PO2; SBE

RECOVERY

EXTUBATION
TEMP
ANES. TIME
ICU
P.O. ANALGESIA
mg,G

SMALL ANIMAL ANESTHESIA RECORD

Figure 2. Continuation of anesthesia record for Case #2.



NYS COLLEGE OF VETERINARY MEDICINE—CORNELL UNIVERSITY

DIAGNOSIS: Fractured Tibia/Fibula
PROCEDURE: Fracture Fixation — TIME SCHEDULED
SURGEONS: Trotter/Lussier
ANESTHESIOLOGIST: Looney — ANESTHETIST: Nezezon
STALL / CAGE#: G11 — DATE: 2/4/92
ANESTHETIC RISK: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ E ☐

WT	HR	R.R	CRT	M.M. COLOR
52 lb	100	18	<2 sec	pink
TEMP. 102.4	PCV 93	T.P. 6.8	BUN 17	GLU

PRE-MED — BEFORE / AFTER
☐ — AGGRESSIVE — ☐
☐ — EXCITED — ☐
☐ — PAINFUL — ☐
☒ — TRACTABLE — ☐
☐ — SEDATE — ☒
☐ — V DEPRESSED — ☐

DRUGS IN LAST 24 HOURS

	PRE-MED	DOSE	ROUTE	TIME	IND DRUG	DOSE	ROUTE	TIME
1	Acepromazone	2mg	IM	8:00	Ketamine	60 mg	IV	9:30
2	Glycopyrrolate	.20mg	IM	8:00	Valium	3 mg	IV	9:30
3	Oxymorphone	2mg	IM	8:00				
4								
5								

TIME 13 — 15 30 45 — 15 30 45 — 15 30 45 — 15 30 45

IV Fluids: 1/2 DEX 1/2 LRS 100/600
Medication: Oxymorphone 1 cc IM 1 cc IV

AGENTS: O2 L/min; N2O; HALO; ISO 2.0 1.5 1.0 .5; F/S

Plane: Light / Deep

Anes A; End Anes (A); Proc (·); End Proc (X); Rad R; End Rad (R); Sys; M x; Dias; Pulse Rate; Vent; Spon S S; Assist A A; Cont C C

200 180 160 140 120 100 80 60 40 30 20 10

IPPV — TV / BPM

COMMENTS

TOTAL (ml,L) (mg,G)
600 ml LRS IV
Glycopyrrolate .2 mg IM
Cefazolin 520 mg IV
Oxymorphone 1cc IM 1cc IV

MONITORING
☒ ECG ☐ TEMP
☐ D-BP ☐ CVP
☒ I-BP ☐ VBG
☐ ABG ☐ OTHER
☐ DOPPLER

AIRWAY MAINT.
☐ MASK
☒ ETT SIZE 11
☐ NTT SIZE

SYSTEM
☒ SEMI-CLOSED
☐ CLOSED
☐ NRB
☐ OTHER

ANES COMPLICATIONS

	PRE	ANS	POST
CNS	☐	☐	☐
CV	☐	☐	☐
RESP	☐	☐	☐
METAB	☐	☐	☐
M/S	☐	☐	☐
OTHER	☐	☐	☐

ARTERIAL BLOOD GAS
TIME
PH
PCO2
PO2
SBE

RECOVERY
EXTUBATION 2:15
TEMP. 95.2
ANES. TIME 4:05
☒ ICU
☐ P.O. ANALGESIA _____ mg,G

SMALL ANIMAL ANESTHESIA RECORD