

# 7UDQVSODQWDWLRQ 7HFKQRORJLHV 5HVHDFK

SOH[DQGHU HW DO - 7UDQVSODQW 7  
KWWS G[ GRL RUJ

5HVHDFK \$UWLFOH

2SHQ \$F

\* OEVDUJPO PG )ZQPNFUBCPMJTN BT B /PWFMA  
3FQFSGVTJPO \*OKVSZ JO 3FOBM 3FDPOTUSVDU

%REE\ \$OH[DQGHU -D\$QGHZ )LVKQERDHO \*DQGVKDPPEL 'RUDL  
'HSDUWPHQW RI 8URORJ\ 1HZ <RUN 0HGLFDO &ROOHJH 86\$  
'HSDUWPHQW RI 3KDUPDFRORJ\ 1HZ <RUN 0HGLFDO &ROOHJH 86\$  
&RUUHVSQRGLQZKDRWKRRUDL 'HSDUWPHQW RI 8URORJ\ 1HZ <RUN 0HGLFDO &ROOHJH 'DQD 5RDG %DV  
86\$ 7HO ( PDLO WKDPELBGRUDL#Q\PF HGX  
5HFHLYHGDWH \$FFSWHG-SOMH 3XEOLVKHGXWH  
&RSULJKW \$OH[DQGHU % HW DO 7KLV LV DQ RSHQ DFFHVV DUWLFOH GLVWULEXWHG XQGHU WKH W  
XQUHVWULFWHG XVH GLVWULEXWLRQ DQG UHSURGXFWLRQ LQ DQ\ PHGLXP SURYLGHG WKH RULJLQDO DX

## \$EVWUDFW

3XUSRWLEHUQDWLRQ LV DQ DOWHUG SK\VLORORJLFDO VWDWH ZKLFK LV PDUNH  
WHPSHUDWXUH DQG H[WUHPH PHWDEROLF UDWK GHSUHVVLORQ 'XULQJ WKLV SHULR  
LWV KHDUW UDWK DQG EORRG IORZ GHFUHDVH WR DQG LWV R\JHQ FRQVXPS  
OHYHOV (YH WKRXJK WKHVH SK\VLORORJLFDO SDUDPHWHUV PLPLF FRQGLWLRQV R  
KHDUW OLYHU DQG NLGQH\V GR QRW VKRZ DQ\ GHWULPHQWDO HIIHFW RI VHYHU  
RXW RI KLEHUQDWLRQ :H ZLVKHG WR H[SORUH WKH EHQHILWV RI LQGXFLLQ VXF  
UHSUHVLRQ LQMXU\ PRGHO

0HWKRGLQYHVWLJDWHG WKH SUH FRQGLWLRQLQJ HIIHFW RI DGPLQLVWHULQJ  
PLFH WR FUHDWH D VWDWH RI K\SRPHWDEROLV DNLQ WR KLEHUQDWLRQ 7KLV  
SURWHFWLYH HIIHFW RQ D VXEVTXHGW UHQDO LVFKHPLF HSLVRGH

5HVXOWU UHVXOWV VWURQJO\ VXJJHVW WKDW DQ LQGXFWRQ RI D K\SRPHWDER  
DQG UHSUHVLRQ GDPDJH WR WKH NLGQH\ DV VWXGLHG E\ VHYHUDO VSHFLILF S

&RQFOXVLRQRQFOXGH WKDW UHSURJUDPPLQJ RI WKH NLGQH\ PHWDEROLV WR  
LVFKHPLD PD\ SURWHFW WKH RUJDQ IURP R[LGDWLYH GDPDJH DQG UHGXFH LVFKH  
DOVR EH DSSOLFDEOH WR LPSURYH FOLQLFDO RXWFRPHV LQ UHQDO UHFRQVWUXFW

.H\ZRUG,WFKHPLD UHSUHVLRQ LQMXUWKHSHPHWDEROLV 3DUSWDO UHYHUWHG  
QHSKUHFWRP\ :DUP LVFKHPLD d \$GHQURVROVDORQHSKRGSZKWWKHU GDLO\ RU VHI

## ,QWURGXFWLRQ

/LYLQJ RUJDQLVPV DUH IDFHG ZLWK PRVWPHDPPDOWGHRUHQVHUQDQDERXQ  
H[WHUQDO VWUHVVRUV WKURXJKRXW WKDW H GKHU GJFQKHILUUDZNRKHQWULHNS RQD  
ZD\ E\ ZKLFK WKH\ FDQ FRQWULXHSRQHFKYDWHLQ QWHLU FRUH ERG\ WHPSHU  
LQYROYH DGMXVWPHQWV LQ FHOXODU PHVVDERQVPLQWRE RGHWPHSHGHBDQXV DR  
WKH VDPH WLPH VWULYLLQJ WR PDLQWDELQD WRODQFOR GHWZHHQDWHLQQXDDPP  
SURFHVVHV ,Q FDVHV RI H[WUHPH KHDLP FROLQWDFN HQWHUHQSPHKWDEROLV R  
IRRG GHSULYDWLRQ FHUWDLQ RUJDQLVRO GJRWVQRXZQ KWRRPHVWDERDUPXQGHU  
VXUYLYDO PHFKHQMPUDQFHLQWR D K\SRPHWDEROLVFKLVWUHQDWRUV LQFUHDVHV  
WRUSRU LV WKH ERG\DV DWWHPSW WRSPURGLPLH HQWHUHQSHVGHVGRGHUHQPSWGR  
FRQVHUYH HQHUJ\ XQGHU PHWDEROLVHQWUHXFDQXVHQDQWDLQ WKHLU SK\VLRO  
QXWULHQW VXSSO\ ,Q FHUWDLQ DQLP DQVHO SRYPHWDEZLGH VWULVWVROUHQLOVHU  
SDUWV RI SKHQRPHQD LQFOXGLQJ KLEHUQDWLRQPHWDEROLVWVHRDW GLDPSRYDHLQDQ  
DQDHURELRLV > @ 'XULQJ WKH ZLQWLUVFDYRQUPHWDEROLKXPDVHVRG\ WKH  
KLEHUQDWLRU VXFK DV EHDUV DQG JURXQGVOTXLRQHQVWUHUHQVSSUMVHGLW\ RQH  
DQG WKHLU FRUH ERG\ WHPSHUDWXULHXVFDQVSRQGHQVWDOHQGRHWPHVIFRPHV  
GHJUHHV MXVW DERYH WKH DPELHQW WHPHSHQVXUHQVWQXIBYDQDORQIDQRQ K  
> @ &HOXODU SURFHVVHV VXFK DV K\SRPHWDEROLVWVHQDQVDFHQWUHQV @VZD  
DV SURWHLQ V\QWKHVLV DUH ODUJHVSXSSUHQVHQUGZHQQV WKLQVSHUWLRGRI WR  
DGHQRVLQH d WULSKRVSKDWH \$73 SURGXFWLRQDURP \$ORFRXQGLQ UHGSUHQVH  
DQG OLSLGV VHUYH DV WKH PDMRU KVSXSHUHQWHQ DQG WKHWHUHQPHWDEROLV U  
UHTXLUPHQWV > @ +RZHYHU WKH XQVXUHQVDFRXLWKLQVWUHQVBUV@LV<WWD

&LWDWSRQIDQGHU % -DPHV 0 )LVKPDQ \$ \*UDVVR 0 'RUDL 7 ,QGXFWLRQ RI +\SRPHW  
5HSHUHXVLRQ ,QMXU\ LQ 5HQDO 5HFRQVWUXFWLRQ GRUHLHV -7UDQVSODQW 7HFKQ

3DJH RI

WKHLU KLEHUQDWLRQ VWDWH WKHLU VEHUHLQW HGL GRUHMDFX QUR XSQ G WDKVHLLUW KHFD  
VSULQJ EDFN WR QRUPDOFH\DIDIRRMWMM KLP RWHZL ZVHSDQRYD WHVW ZKHQH YHU QHFI  
PHFKDQLVPV RI LQGXFWRQ RI D \SRPHWDEROLF VWDWH LQ WKH VH KLEHUQDWRU  
DQG LQ VRPH QRQ KLEHUQDWRUV DQG QYKF WLFH QDR LKRS RPH HAN DER OVKP K \SR  
SUHVHUYH WKHLU RUJDQV LQ VSRZKDR H ELPDHOV UHO UHVWULFWHG EORR  
EHHQ XQGHU JUHDW LQYHVWLJDWLRQ QRW RQO IRU WKHLU XQLTXH QDWXUH E  
DOVR IRU WEDQWSDULRQDFX DOUO IRU WDRQLQSLVWVWLRQ RI d \$GHQVRLQH P  
FIWRSURWHFWLYH UROH LQ WKH FOLQLFDV QWWDQQALWY DRH PVRFHQLHDFKUL  
LVFKHPLD RU VWURNH > @ \$OVR BSSOHFWWKKI \$03 WRQI \FRQVXV WFRH YHG  
K \SRPHWDEROLF PHUHJDDO ERVH HOFVJUDOSI SKRVSKDWHH WDC LQH 3%6 RI d \$03 H6LJPD  
UHQDO WUDQVSODQDWRQ ZKHUH WKH BDDOM HQMHLRQ RYQWKR DQW BHHW DER  
GRQRU NLGQH \ LV RI SDUDPRXQW LPSR OWWVPH RU QR \$S HULFDQDFRQVLYWV V RQ  
IRFXVHG RQ WKH LQGXFWRQ RI D ZHHRPHV DEROLF FOLDFRHEFRQW V H RQDH  
DGPLQLVWUDWRQ WKR WKR R K J HDV HRXV RSHKRRLFO PHRQW 8QGHU WKH V HRG  
> @ PDL GUDZEDF RI WKLV DSGKFR WR OMKVWV WDKLV I &RHV RWHUERB  
JDVRWUDQVPLWWHU OLNH FDUERQ PRVWRSHU DWXUVLQW % 7FRZV L GRQOZHHFR OX  
SRLVRQ E WQKDFR B O W Q DWWHQXDWLQJ D GHLQV LW FWH R D ZLWK WKH KHOS RI D U  
UHSHUHXVLRQ LQMXU\ DW H[WUHPHO \ ORZ FRQTHDWRU DW GRQSS HQ WFORW KH DW R V K E  
WR[HFFHW DW KLJKHU FRQFHQWUDWLRQ FO KL DWOL FRQV R Q R QHG O B D B R U DQG ZD V  
WKHUDSHXWLF ZLQ FVRZKRQW V R O LQ FOLFL B O VXLP V DW R Q R Q W H ZD V I R O R Z H G  
SDUWLXFWWUO \ UHDO L J D W L R Q G W O B V W W X S E R D O D [ W H V V F K D P E H U V I D O G F 2 H T V R L S S  
VRGLXW O B C H G V K G L R V X O B G H Q G 1D+6 D & R O X P E X V Q V W U X P H Q W V , Q F & R O X P E X V  
DFWLQJ DQG GR QRW JLYH6D>FRQ WQQW R W W U H O H P R U L H W K H L U D E L O L W \  
IRU D VDIH H F O L O W H U Q D W L Y H D S S U R I H W V R V L X G H V L O R G D W H U P L Q H W K H L U D  
K \SRPHWDEROLF VWDWH ZH FDPH DFURVHS W K V SRQ O Z K K F G Z D P X W W K K I \$ 0 3 P L Q G S  
KLV JURXS > @ ZKLFK IRFXVHG \$ V H W K W D Q L P D O X F W K H S L K D W L R U U W K H U Z H U  
K \SRPHWDEROLF VWDWH E \ WKH D H V X E H W O R U L R O H P R E V H M M O D Q L P D O V U H F  
PRQRSKRVSKDWH d \$03 ZKLFK LV SUHVHUYH D Q P W W E R O F L V D O V H W K H L Z H U H  
HYHU \ F H O O R I W K H E R G I E H G U H F L Z E V F V H L E H S W K H D W U R R P W H P S U R D W R K B  
DGPLQLVWUDWLRQ RI d \$03 LQ SUHBUWHH W D S P H W K E R D G B S U H Q F R Q H W L R Q L Q J Z D V U  
LVFKHPLF HSLVRGH DQG VXJJHVW WKDW WKLV FRXOG EH D VDIH DQG QRQ WR[LF  
ZD \ WR SUHVHUYH WKH JOREDO SDUHH D E R K U H D O D O X F W K K H P R D W K H N L G Q H \ L Q  
FOLQLFDO VLWXDWLRQV VXFK DV UHQDO UHFRQVWUXFWLRQ VYUJHULHV DQG SD  
QHSKHUFWRPLV ZKHUH WHPSRUDU \ UHDO D D U W K L V D G F O X Y V R O D W L R D U N D D G W H L  
2XU HDUOLHU VWXGLHV KDYH GHVFULEH G V I H J U D O W S S H Y H B E A S O B I L O G G F H G K I S R P  
ZDUP LVFKHPLD WLP H L Q S D U W L D O Q H S K U H F W R I Q H S U R F H G X U H V \$ 0 3 L Q G X F H G K I  
, QGXFWRQ RI \SRPHWDEROLV FRXOG E R F H W F D S D E W L U W P R W P H W D E R O L R H X R O H D  
UHQDO LVFKHPLD DQG UHSHUHXVLRQ L Q M X U \ F R S X O G H U D O P O P H W G H V L D P W W L Y H  
EHQH \ W W H Q S D W L H Q W 2 X U U H V X O W V V W U R Q O J O D F R G S U G I O W W R K W H G S U R W R F R O W H  
WKH DFWDLYDWLRQ RI WKH HQJ \ P H \$ 0 3 D F W L Y F W H G S H U G O D O H P B X K D O D W W K O W  
NLGQH \ P D \ S O D \ D Q L P S R U W D Q W U R O H F O L W U D Q V L V W F Q W F G E K H \ U H V K G M H H R O Q  
VLJQDOV WKDW ZR X O E W R W L W Q D D W L V W K H P L V F K H H L V L Q G X F H G E \ F O D P S L Q J W K H U H  
L Q M X U \ P L Q X W H V H V H Q W L D O O \ D F F R U G L Q J W R W

ODWHULDOV DQG OHWKRGV

\$QLPDOV

)HPDOH & % / P L F H Z H N V R I D Y E M F L W H G Q W E H \$ 0 3 S U H F R Q G L W L R Q L Q J  
DQG JUDPV ZHUH DFTXLUH IURP & K D U O H V L Y H U / D E R U D W R L U H V D O G  
DFFOLPDWLJHG WR WKH FRQLWLRQV L O W K H D Q L P D O U H V H D F E K I D F L O L W \ L C  
SURFHGXUHV ZHUH SHUIRUPHG LQ DF R U G D O D E H L V F K H P L D U R F H G X U H R Q Q \ Z L V  
SURWRFROV RI WKH , Q V W L W X W L R Q D O \$ 0 3 P D O D Y H D Q G D O O \ W P L V A O H G , V F  
, \$ & R I W K H , Q V W L W X W H R I & R P S D U P W L Y H R G I G L F S L O I L D V W K H I H Z < R U N  
OHGLFDO & ROOHJH OLFX ZHUH PDLQWDLQHG LQ WKH IDFLQW ZLWK D VWDQGDU  
KRXU GDUN OLJKW FFOH DQG WKH \ K D G D F F H V V W R I R R G D Q G Z D W H U D G  
OLELWXP \$ W W K H H Q G R I W K H D F F O L P D W L R Q S H U L R G L P P X Q R K L V W R H I P L V  
UDQGRPLJHG LQWR JURXS RI DQLPDOV KDUWKDW R W H G J U R X S Q H L V E K H P P Q V Z H U  
RQO \ g JURXS f \$ 0 3 R Q O \ g JURXS D Q G H I D P L Q D W L R Q E K H R L D Q W L R Q S \ D V G H V F U L  
3RZHU DQDO \ V L V Z D V S H U I R U P H G I R U D U L Y L Q O L R A H W K P H Q R G Z H U H X H R H P D O Y Q I  
K R X U V D Q G W U D Q V I S U H H B E W G S L O W D V Q D G

&LWDWSDQ[DQGHU % -DPHV 0 )LVKPDQ \$ \*UDVVR 0 'RUDL 7 ,QGXFWLRQ RI +\SRPHW  
5HSHUIXVLRQ ,QMXU\ LQ 5HQDO 5HFRQVWUXFWLRQ GRULJULHV - 7UDQVSODQW 7HFKQ

3DJH RI

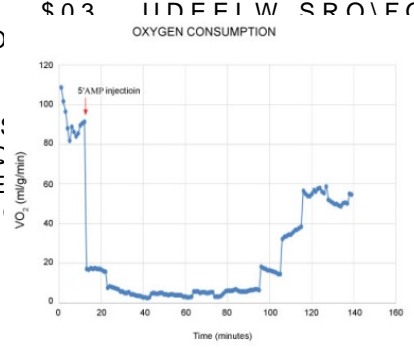
wP WKLFN VHFWRQV ZHUH PDGH DQGHV SHFLVHG QLWK DRHODWRQWIRQ DRQCK WK  
HRVLQ + ( XVLQJ VWDQGDUG SURFHGXUHV YHWWRI WUKHDOOHODV MKYGRQVGRZURSH  
SURFHVVHG IRU6HULRGLFWSFLQLQJ OHZKODUWVXWXODRI\JHQ FRO WKPLSWHROWUD  
QHFURVLV ZDV DVVHVVHG DQG VFRUHG %DVGGRSSHG VDG QHDOHLRSHG W@ DJRLKQ  
,PPXQRKLWRFKHPLFD GHWHSULRGLDQWLYH VHWRRGVPDQW HQDQFH\ \$KDVH  
VHFWRQV RI WKH NLGQH\ LQ WKH H\ \$RIULVFKHQWQWJURZSDW EDDERWVKHOZD OFU W  
DYDLODEOH NLW ZDV XVHG 2[\,+& R\LG DWLYKHZ\QWUQV VJGWHWH\$VDRQ NLWXULQD VSK  
&RUSRUDWLRQ %LOOHULFD 0\$ IROORZIDJ QWKHSDURFHGX WVKH ISU HQFWRE @GUDWMMK  
PDQXIDFWXUHU PRQLWRU GDWD QRW VKRZQ )LQDOO\ WI  
&%7 DV ZHO@PDVEZFN WR QHDU QRUPDO D

(VWLDPDWRQ RI VHUXP FUHDWLQLQ FRIQ WRPH PD @HPD@ WUKH \$Q RI WKLV DUF  
LVZDV GRQH HVVHQWLDQQ\ DV GHVFULG HQWH XVOHQJ \$HFRPH FLRW @ Z  
DYDLODEOH FDORULPHWULF NLW &D\ RRQ@ \$KDLFDSUH @SUH \$UHV UHSHDWHG  
> @ \$V DQ LQGSHQGHQW SDUDPHWHU L\JHG D VY WSUHLRQ OLWLHQZJ P HW  
DOVR IROORZHG VHH EHORZ HSLVRGH UHQDO LVFKHPLD 2Q GD\ WKH  
,PPXQREORW DQDO\VLV K\SRPHWDEROLVPHWLFV RI WKH ORZHULQ

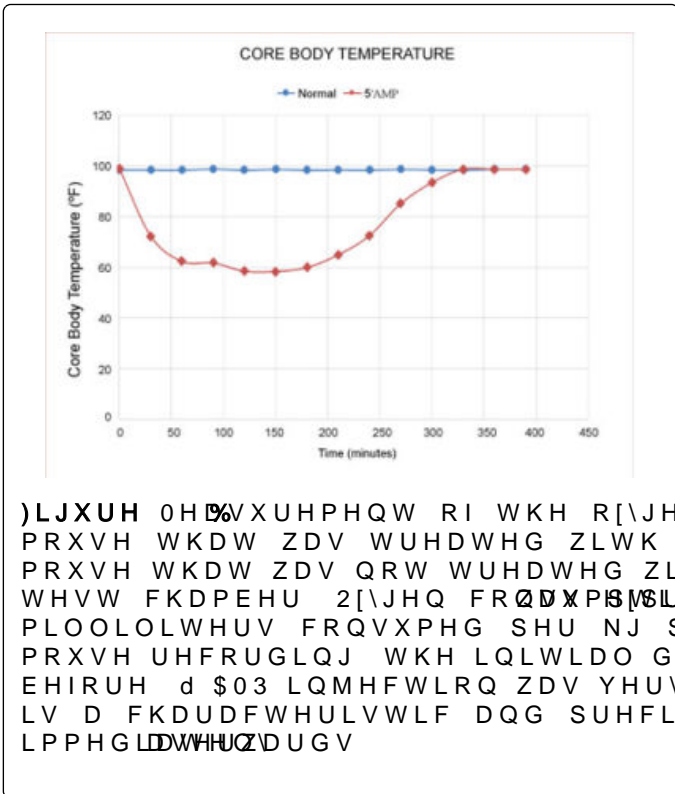
H SURWHLQ DQDO\VLV SURFHGXUV WHPSHUDWXUH RIJHQ FROYXPSWLRQ UDV  
HDUOLHU > @ 6HUXP VSHFLPHQV ZHUH WUKDW WVKHULV DRI ZLQGRZ RI PSSRUW XQ  
HQQ SRLQW IRU WKH YDULRXV JURXSV DV FRYFRFULEHG NLGGQHV YH DQVNHQ\ V  
PLFUROLWHUV RI WKH VHUXP VSHFLPHQV FV FZHUH FVEMDFWHG ZKHQ D GHODD\ DUW HU  
JHO HOHFWURSKRUHVLV EORWWHG RQW HULRURWUH FROXWHRQ W @ P DNY G @G\ \$U  
ZLWK D FRPPHUFDOO\ DYDLODEOH F\ VWUWIFDQWLDQ @FQDO@ ELQTRQW @ 6L JODJ @QW  
'DQYHUV 0\$ 6LPLODUO\ LPPXQREORW LV DQDQDYLVG ZDV SHUWRUPHG XVVLQJ SURG  
GHQDWXULQJ JHOV RQ QRUPDOLJHG SURWHLQ HLUWDFWV @PFGHPLRPSUH FRO  
YDULRXV VSHFLPHQV FROOHFWHG ZLWK FORENLQDFV PLON@SKRWR 6DQWD  
&UX] ,QF %LOH @LQH 7%6 FRQWDLQ ZDY GRQZHG GHVFULHGLQ )LJXUH DQ  
3URWHLQ HVWLDPDWRQV ZHUH SHULRUPHG WKHLU EDJHV WR VWDW D UHSHUIXVLRQ \$  
'HUPR\LV\K @VHUHPRYLQJ WKH LQWHUIHU@V XVEVWDO@FHQG SRD@W@L@G@V@DL@LD@V@K@H  
&RPSDW \$E@H SURWHLQ D @V @V @SH @SD@P @ZHO@D @V WKH FROWUD @D @W @H @D @NLG@QH@V@  
,QF TXUWKHU DQDO\VLV DV GHVFULHGLQ EHORZ  
DOVR SUHSDUHJ IURP WKHVH DQLPDQMX

(OHFWURSKRUHV FHG SURWHLQV RQ W @ H @ D W D Z H W K H \$ U R F H G \$ Z L W K D Q W W K R I G E  
IRU JDOHFWLQ PRXVH PRQRFORQDO \$DQW @ X\ @ O @ H @ X @ F L Q PRXVH  
PRQRFORQDO 6DQWD &UX] ,QF 1HXWURSKLO DVVRELDWHG JHODWLQDQVH  
1\*\$/ UDEELW SRO\FORQDO 6DQWD &UX] ,QF \$03 IIDEFIW SRO\FORQDO  
6DQWD &UX] ,QF \$KR@V@SKR \$ @ V. SRO\FORQDO  
&UX] ,QF \$FH@O @RHQ\PH \$ @DUER\@ODVH  
SRO\FORQDO SKRVSKR \$ & @ S6 \$EFDP ,QF  
&HOO 6LJQDO ,QF UDEELW SRO\FORQDO +\:  
,) @ERYXV %LRORJLFDQV UDEELW SRO\FORC  
JHOV ZHUH URXWLQHO\ PRQLWRUHG E\ SURE  
H\SUHVVLQRI PRXVH • DFWLQ PRXVH PRQRF

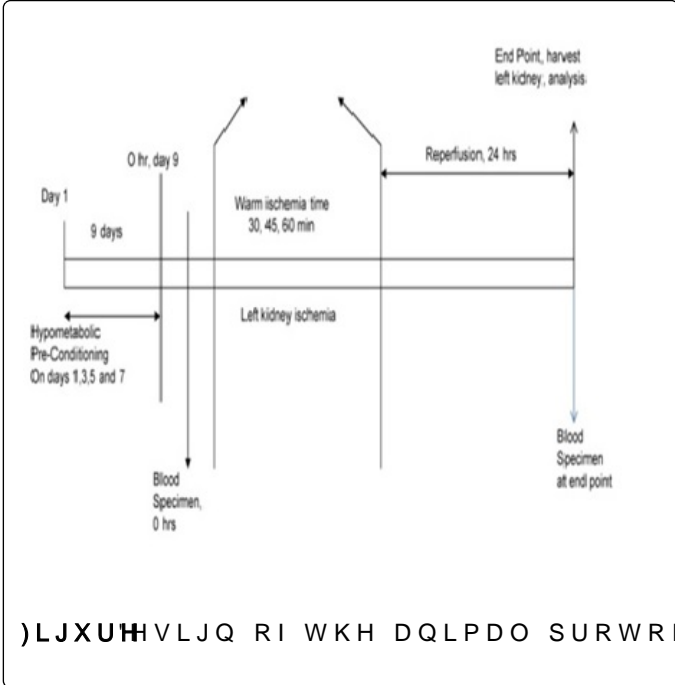
5HVXOWV  
2XU LQLWLDO VWXGLHV IRFXVHG RQ WKH JH  
VWDWH DQG FKDUDFWHUL]DWRQ RI WKH WRU@S @NL @S @D @W @NL@V @LQ @PL@FH @LQ  
@D@ER@U@R@U@ @XQGHU WKH FRQGLWLRQV JHXHLEHG FLE@J R@WH @V @R @H @G @R @W @K @G  
,PPHGLD@WH@WKH LQMHHWLRQ RI d \$03 WKH DQLPDQV@W@H @P@R@Q@R @UH@G @L@D@P@R@Q@V  
WRUSU @LNH VMDWH VXJJHWLQJ WKH DQVH \$03 FRYXOG @L@P@L@F @W @D@W @D@I @D  
PHWDEROLF VXSSUHVVLRQ VPH@W@K@I @K@P@H@W@R@P@H@W@S@W @D@D@P@L@H@Q@W  
RI d \$03 WKH DQLPDQV ZHUH PDLQWLDL@X @G @L@R @G @H@W @K@R @H@S@L@L@D@V @R @D@I@V@X@U@  
FKDPEHU ZLWK DQ DP@L@H@Q@W WHPSHUDW@H @H@R @R @S @L @Q @D @V @H @F @V@X@U@  
FRROLQJ GRZQ WKH DQLPDO WR QHDU [ & SURGXFHG D EHWWHU DQG GHSHU  
WRUSRU DQG D fVXVSHQGHG DQLPDWR@R@G@ VWDWH LQ WKHVH DQLPDQV D @H@D@W@X@  
FRQ\U@H@H@DU@OL@HU @V@X@S@L@M@V@L@F @S@UDPHW@HU@V IRU WKH  
HVWDEOLVKPHQW DQG WKH GXUDWRQ RI WKLV VWDWH ZHUH PHDVXUH G E\  
IROORZLQJ WKHLU FRUH ERG\ WHPSHUDWXUH DV ZHO@ DV WKHLU R\@JHQ  
FRQVXPSWLRQ UDW H ZKLFK DUH GHVFULHGLQ )LJXUH \$ DQG %







)LJXUH 0H%VXUHPHQW RI WKH R[\JHQ FRQVLPVSWRRO UDWH RI DDOG PLQXWHV  
PRXVH WKDW ZDV WUHDWHG ZLWK d \$03 FOH RQGLD DQG DFRQWHU DV HYD  
PRXVH WKDW ZDV QRW WUHDWHG ZLWK d \$03 UHG OLOH YVLQJ D 2\ODL  
WHVW FKDPEHU 2[\JHQ FRQVLPVSWRRO UDWH RI DDOG PLQXWHV WKH  
PLOOLOLWHUV FRQVXPHG SHU NJ SHU RQGLWLRQHG WKH WUHDWHG WUHDWLYH V  
PRXVH UHFRUGLQJ WKH LQLWLDO GHFRQWHUWLYH RYKHYRSHUFRQVLPVSWRRO  
EHIRUH d \$03 LQMHHFWLRQ ZDV YHU OZNR\ d \$03 HFRQVLPVSWRRO WKH  
LV D FKDUDFWHULVWLF DQG SUHFLSLVSWRPHW WKHP R\JHQ VHYHUVLQJ  
LPPHG LQWHUJUDUGV

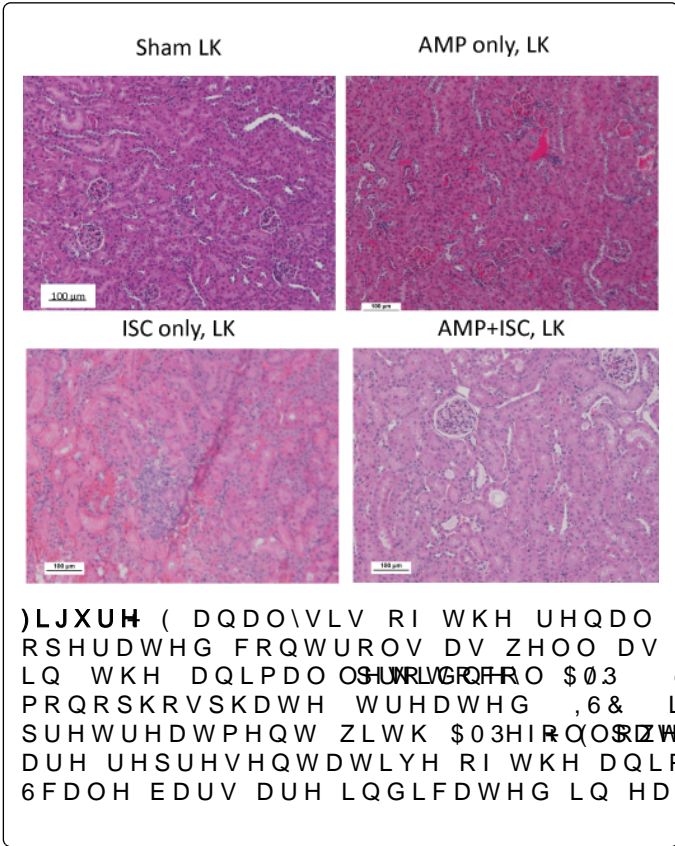


)LJXUH VLJQ RI WKH DQLPDO SURWRRO  
+LVWRORJ\ DQG LPPXQRKLVWLF FKHPLVWLVWLF QDWXURQJLVWLF LQ D FKDUDFWHULVWLF  
K\SRWKHVLV WKDW SUHFRQGLWLRQLVSWRPHWLVWLF WKH LQWHUWALQVWLF QDWXURQJLVWLF  
K\SRPHWDEROLP ZLWK D VXEHTXHQWLVWLF LQWHUWALQVWLF LQWHUWALQVWLF LQWHUWALQVWLF  
VLJQL}FDQW WUHDWLRQ GPDJH FRPSDUHG WKH WUHDWLYH WUHDWLYH WUHDWLYH WUHDWLYH  
VJRZQ LQ )LJXUH )LJXUH VJRZV WKH UHODVLYH LQWHUWALQVWLF LQWHUWALQVWLF LQWHUWALQVWLF  
GPDJH LQ WKH NLGHQVWLF \$03 WUHDWLYH WUHDWLYH WUHDWLYH WUHDWLYH WUHDWLYH WUHDWLYH  
SDQHO LVFKHPLD HFRQVLPVSWRRO \$03 LVFKHPLD

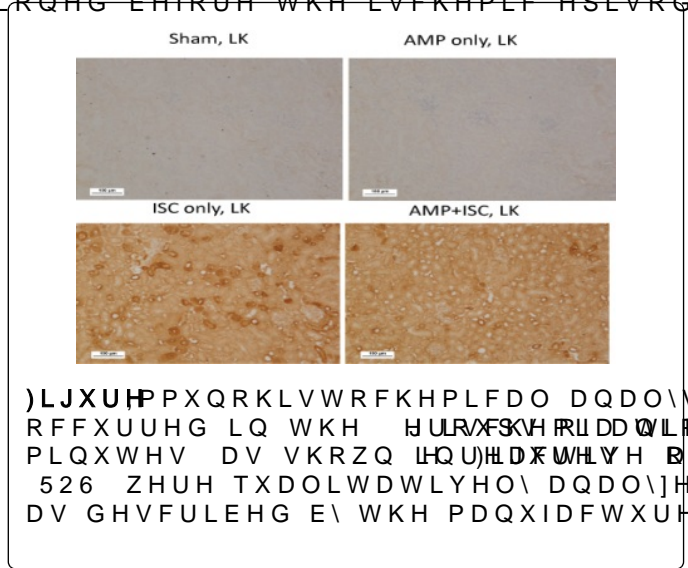
ERWWRP ULJKW WUHDWHG WUHDWLYH WUHDWLYH WUHDWLYH WUHDWLYH WUHDWLYH WUHDWLYH  
UHQDO LVFKHPLD LV VJRZQ IRU FRPSDUD NLGQH\ WKH f\$03 RQO\g NLGQH\ VJRZV  
GDPDJH ,VFKHPLD RQO\ JURXS VJRZHG W ZKLFK LQFOXGHG VHYHUH WXEXODU HSLW  
IUHTXHQW OXPLQDO FORJLQJ :KHUHDV VJRZV LQJQL}FDQW WUHDWLYH WUHDWLYH WUHDWLYH  
RQO\ JURXS )LJXUH VJRZV LQWHUWALQVWLF LQWHUWALQVWLF LQWHUWALQVWLF LQWHUWALQVWLF  
DGMDFHQW VHFWRQV RI WKH NLGHQVWLF GLVWLQJXLVKHV WKH EUXVK ERUGHU RI WK  
VKDP RU \$03 RQO\ NLGQH\ WKH LVFKHPL FHOOGHJHQHULVWLF LQWHUWALQVWLF WKH EUXVK ER  
ORQJHU OLQHV WKH UHQDO WXEXOHV DQG IRUPDWLRQ LQ PDQ\ DUHDV &KDUDFWHU  
JURXS VJRZHG OHVV EUXVK ERUGHU GDF VLJQL}FDQW WUHDWLYH WUHDWLYH WUHDWLYH WUHDWLYH  
WXEXODU QHFURVLV ZDV VFRUH H\HFRQVLPVSWRRO YDOXHV ZHUH  
LVFKHPLD UDWH RI DDOG PLQXWHV d \$03 FOH RQGLD DQG DFRQWHU DV HYD  
PRXVH WKDW ZDV QRW WUHDWHG ZLWK d \$03 UHG OLOH YVLQJ D 2\ODL  
WHVW FKDPEHU 2[\JHQ FRQVLPVSWRRO UDWH RI DDOG PLQXWHV WKH  
PLOOLOLWHUV FRQVXPHG SHU NJ SHU RQGLWLRQHG WKH WUHDWHG WUHDWLYH V  
PRXVH UHFRUGLQJ WKH LQLWLDO GHFRQWHUWLYH RYKHYRSHUFRQVLPVSWRRO  
EHIRUH d \$03 LQMHHFWLRQ ZDV YHU OZNR\ d \$03 HFRQVLPVSWRRO WKH  
LV D FKDUDFWHULVWLF DQG SUHFLSLVSWRPHW WKHP R\JHQ VHYHUVLQJ  
LPPHG LQWHUJUDUGV LVFKHPLF HSLVRGH RFFXUWHW WKH \$03 SUR  
IXQFWLRQLQJ LQ WKH LVFKHPLF NLGQH\ UHODWLYHO\ OHVV R[LGDWLYH VUHVV LQ  
WR WKH RWKHUFRQVLPVSWRRO WUHDWLYH R[LGDWL VJRZQ LQ )LJXUH O\VLV GHWHFWV WKH QLW  
WKSUDUDYHPEHGGHG VHFWRQV RI VUHVV SURGXFWLRQ RI UHDFWLYH R[\JHQ VSHFL  
XVLQJ DQWLERGLHV DJDLQVW QLWURWURY UHODWLYHO\ OLWOH RU QR R[LGDWLYH  
\$03 RQO\ JURXS DQ LQWHQVH 526 VWDLQL JURXS ZKLOH WKH VDPH VWDLQ LV JUHD  
LVFKHPLD LQWHUWALQVWLF LV TXDOLWDWLYH VXSSUHVVLQJ DQG LQGXFWRQ RI K\SRPH  
FRQGLWLRQV WKH NLGHQVWLF RYKHYRSHUFRQVLPVSWRRO RUJDQ DJDLQVW D VXEHTXHQW LVFKHPL  
DJDLQVW LVFKHPLF GPDJH RI WKH NLGQH WKH\ LQGXFHG D K\SRPHWDEROLF VWDW  
VXO}GH > @

:H QH[W SHUIRUPHG DQ H[WHQVLYH DFRQVLPVSWRRO PDUNHU SURWHLQV IRU WKH YDULRXV JUR  
VJRZQ LQ WKH )LJXUH :H IROORZHG WKH LVFKHPLD PDUNHU QDPHO\ JDOHFWLQ >  
JHODWLRQDVH DVVFLDWHG OLSRFDLQ DYDLODEOH DQWLERGLHV :KLOH WKH OHY  
DOW WKH EDVH OHYHO IRU WKH VKDP JURXS WKHVLQJ}FDQW WUHDWLYH LQ WKH LVFK  
DQLPDOV DUH VXEHHFWHG WR DQG +LVWRORJ\ DQG LPPXQRKLVWLF FKHPLVWLVWLF QDWXURQJLVWLF  
K\SRWKHVLV WKDW SUHFRQGLWLRQLVSWRPHWLVWLF WKH LQWHUWALQVWLF QDWXURQJLVWLF  
K\SRPHWDEROLP ZLWK D VXEHTXHQWLVWLF LQWHUWALQVWLF LQWHUWALQVWLF LQWHUWALQVWLF LQWHUWALQVWLF  
VLJQL}FDQW WUHDWLRQ GPDJH FRPSDUHG WKH WUHDWLYH WUHDWLYH WUHDWLYH WUHDWLYH WUHDWLYH WUHDWLYH  
VJRZQ LQ )LJXUH )LJXUH VJRZV WKH UHODVLYH LQWHUWALQVWLF LQWHUWALQVWLF LQWHUWALQVWLF LQWHUWALQVWLF  
GPDJH LQ WKH NLGHQVWLF \$03 WUHDWLYH WUHDWLYH WUHDWLYH WUHDWLYH WUHDWLYH WUHDWLYH  
SDQHO LVFKHPLD HFRQVLPVSWRRO \$03 LVFKHPLD

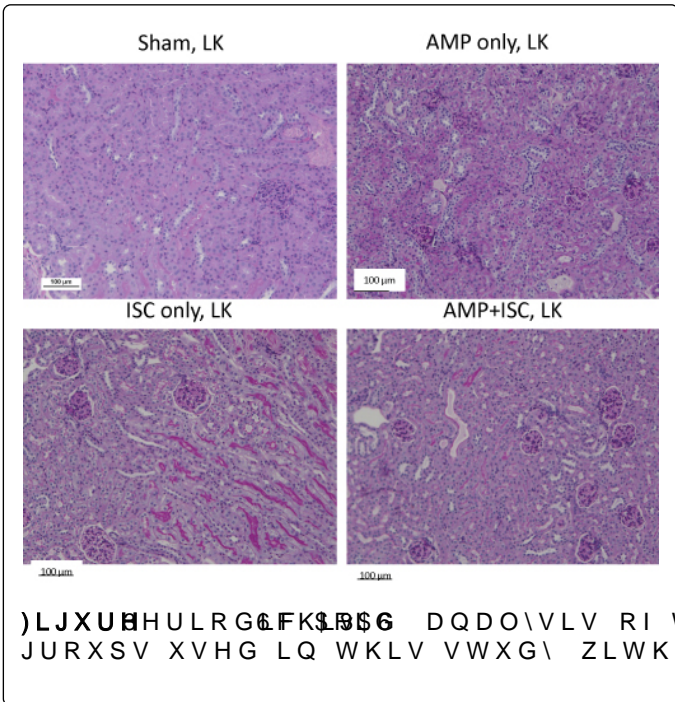
ZKHQ WKH DQLPDOV DUH SUH FRQGLWLRQHG EHIRUH WKH LVFKHPLF HSLVRGH DV  
VKRZQ LQ )LJXUH > @



)LJXUH ( DQDO\VLV RI WKH UHQDO RSHUDWHG FRQWUROV DV ZHOO DV LQ WKH DQLPDO SURVLGRPHO \$03 PRQRSKRVSKDWH WUHDWHG ,6& SUHWUHDWPHQW ZLWK \$03HIRQORZWH DUH UHSUHVHQWDWLYH RI WKH DQLPDO 6FDOH EDUV DUH LQGLFDWHG LQ H



)LJXUH PPXQRKLVWRFKHPLFDO DQDO\VLV R RFFXUUHG LQ WKH HULFSKHRIDDWLPDOZD PLQXWHV DV VKRZQ LQ UHDFXWLYH DQG 526 ZHUH TXDOLWDWLYHO\ DQDO\]HG XV DV GHVFULEHG E\ WKH PDQXIDFWXUHU 6F



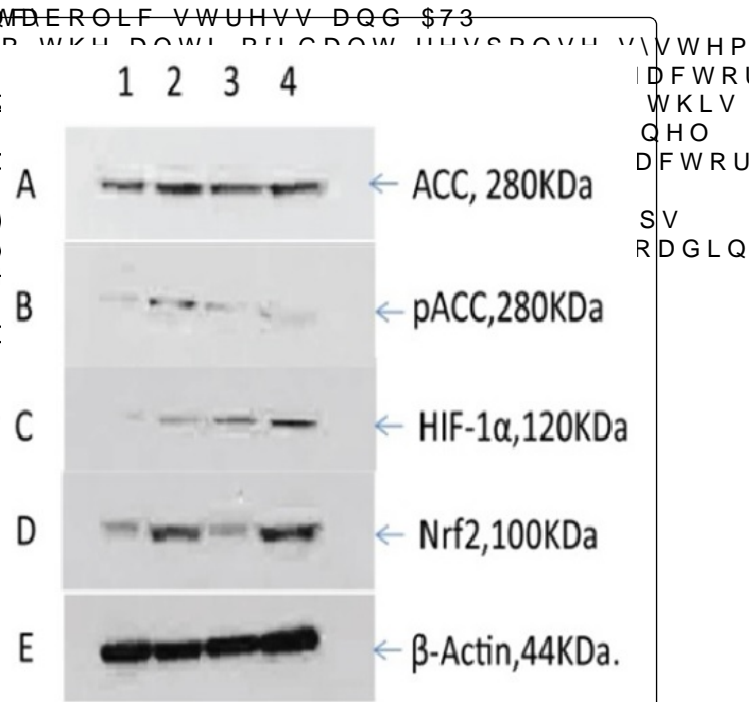
)LJXUH HULRG 6FDOH DQDO\VLV RI WKH JURXS XVHG LQ WKLV VWXG\ ZLWK

\$V DQ LQGHSHQGHW \$03 DQDO\VLV RI WKH UHQDO RSHUDWHG FRQWUROV DV ZHOO DV LQ WKH DQLPDO SURVLGRPHO \$03 PRQRSKRVSKDWH WUHDWHG ,6& SUHWUHDWPHQW ZLWK \$03HIRQORZWH DUH UHSUHVHQWDWLYH RI WKH DQLPDO 6FDOH EDUV DUH LQGLFDWHG LQ H XQSKRVSKRU\ODWHG YHUVRQ RI \$03. LV WKH DFWLYDWHG IRUP RI \$03. LV XS UHJXO WKH \$03 LVFKHPLD JURXSV OBUHDOGWO KLJKO\ VXJJHVW WKH DFWLYDWHG YHUVRQ E\ DW WKH OHDVW LQ SDUW E\ WKH DFWL DPRQJ RWKHU PHFKDQLVPV \$OO WKHVH S FRQVWDQW SURWHLQ ORDGLQJ FRQGLWLR SUHVHQFH RI WKH KRDFWNLGHSHQW SZRWR SURWHLQ H[SUHVVRQ OYHOV RI \$FWLQ LQ )LJXUH SKRVSKRU\ODWHG YHUVRQ RI \$ IRU WKH DFWLYDWLRQ RI \$03. ZKLFK UHFH E\ d \$03 DPRQJ RWKHU DJRQLVWV > @ :K \$&& LV QHDOU\ FRQVWDQW LQ VKDP SDQH ODQH LVFKHPLD RQO\ SDQHO \$ ODQH ODQH JURXSV WKHUH LV D DQ DFWLYDW SDQHO % ODQH DQG \$03 LVFKHPLD J IROORZHG REASER \$03 DFWLYDWHG YHUVRQ \$03. DFWLYDWLRQ LV IXQFWLRQDO ZLWL LQKLELWLRQ RI IDW\ DFLG V\QKHVLV E SUH FRQGLWLRQLQJ SURWRFRO GHVFULEH DQG GUDVWLF UHGXRZLWV QWKG N\KGHEORZK UHVHPEOHV D PLQRU LVFKHPLF HSLVRGH VWDELOL]DWLRQ RI WKH K\SR[DFXWLYH LV N\GHLWLV DXP \$03 VKRZQ LQ )LJXUH SD L\LVFKHPLF EDUHG YHOV LQ WKH JURXS UHJXODWHG LQ \$03 RQO\ JURXS ODQH }QQDO\WKH \$03 LVFKHPLDVKRZXSWDQHW PHGLDWHG K\SRPHWDEROLVP DQG LWV UH K\SR[LF VWDELOL]DWLWV QWKG R\EH VVDE WKH SURGXFWLRQ RI UHDFWLYH R\JHQ V

&LWDWISDQ[DQGHU % -DPHV 0 )LVKPDQ \$ \*UDVVR 0 'RUDL 7 ,QGXFWLRQ RI +\SRPHWD  
 5HSHUIXVLRQ ,QMXU\ LQ 5HQDO 5HFRQVWUXFWLRQ GRUJHULHV - 7UDQVSODQW 7HFKQ

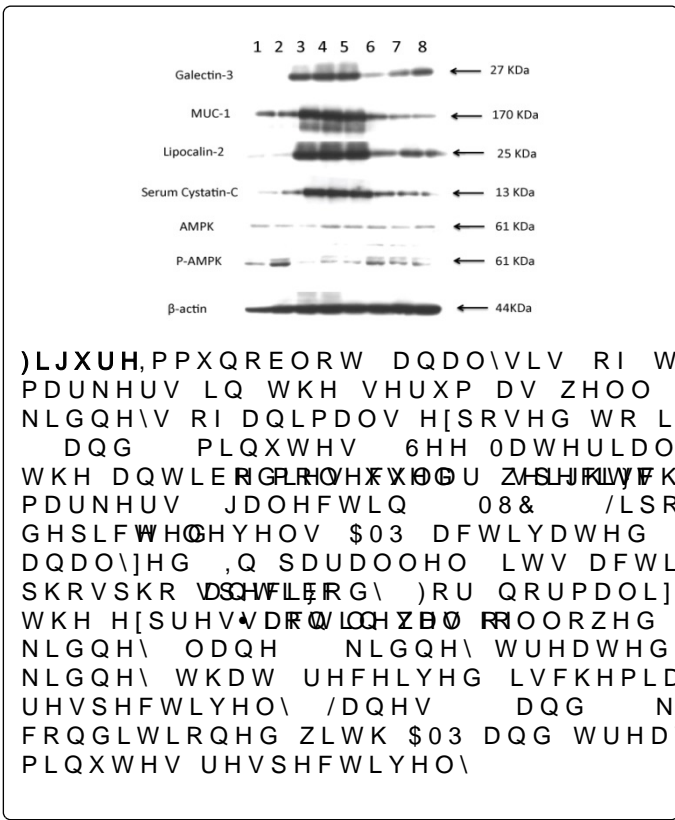
3DJH RI

\$03. LV D PDVWHU fVHQVRUG RI WKH PHO DEROLF VWUHV DQG \$73  
 VWDWHV DQG LW LV FORVHO\ OLQNHG W WKH DOWI PLQDOW UHVSRQVH V VVWHP  
 FHOO ZKLFK LV PHGLDWHG E\ WKH WU IDFWRU 1UI ;  
 HUIWKURLG UHODWHG IDFWRU 1UI ;  
 SURWHLQ LQ WKH IRXU DQLPDO JURXS  
 ' VKRZV WKDW WKHUH LV DQ XS UHJXOL  
 WKH \$03 RQO\ JURXS ODQH DQG WKH  
 FRPSDUHG WR WKH VKDP ODQH DQG  
 ,Q )LJXUH SDQHO ( VKRZV WKH H[SUH  
 FRQWURO\ LQ IRU WKH YDUHRYXOW WURXS  
 K\SRPHWDHFRPHGLDWHG E\ d \$03 LV P  
 FRXOG EH RUFKHVWUDWHG DV WFWHODK  
 \$03 PHGLDWHG VLJQDOLQJ SDWKZD\



7UHDWPHQW	&UHDWLQLQH OHYHOV PRO /
6KDP RSHUDWLRQ	
,VFKHPLD 2QO\	PLQ
,VFKHPLD 2QO\	PLQ
,VFKHPLD 2QO\	PLQ
\$03 RQO\	
\$03 ,VFKHPLD	PLQ
3	6(0 6WDQG DUG (UURU RI WKH 0HDQ

7DEOH HUXP FUHDWLQLQH YDOXHV IRU WKH HSYDURGRXODOR



)LJXUH,PPXQREORW DQDO\VLV RI WKH SURV  
 VKDP ODQH d \$03 RQO\ ODQH LY  
 LVFKHPLD ODQH SUREHG IRU WKH H  
 LVFKHPLD UHODWHG SURWHLQV 3DQH  
 &DUER\ODVH \$& 3DQHO % SKRVSKRU  
 & H[SUHVVLRQ D\XG\URWKH) H[SHULPHQV  
 XVHG 3DQHO ' EDVH DV ZHOO DV WKH  
 WUDQVFULSWLRQ IDFWRU DFMLQDQ\SHV  
 IROORZHG IRU ORDFRULQJH\SRQVROJ PROHF  
 DUH LQGLFDWHG

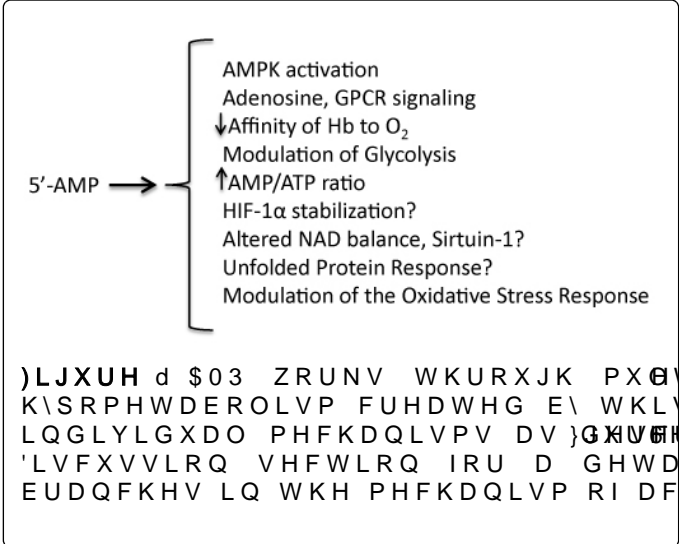
'LVFXVVLRQ

)LJXUH,PPXQREORW DQDO\VLV RI WKH YDUHRYXU UHODOLVFKHPLD  
 PDUNHUV LQ WKH VHXP DV ZHOO DV FURWLFHQH\UHVSRQVH KHHOKHNSOJH K  
 NLGQH\ RI DQLPDOV H[SRVHG WR LVFKHPLD ODQH UHODOLVFKHPLD ODQH :H E  
 DQG PLQXWHV 6HH ODWHULDOV DQG OHWKRQV IRU WKH VRXUFHV RI  
 WKH DQWLEGRORJXODOR ZSHJRWFKHFWH  
 PDUNHUV JDOHFWLQ 08& /LSRFDOLQ DQG &VWDWLQ & DUH  
 GHSLFWHGHYHOV \$03 DFWLYDWHG NLQDYH \$03 ZD\ DQV FHOO VLJQDOLQJ  
 DQDO\JHG ,Q SDUDOOHO LWV DFWLYDWHG VWDWLQ ZD\ DQV IRORZHG XVLO  
 SKRVSKR DSHWLERG\ )RU QRUPDOL]DWLRQ SURWHLQ ORDGLQJ  
 WKH H[SUHVVLRQ\ODQH ZHOORZHG /DQHVYKDP RSHUDWHG  
 NLGQH\ ODQH NLGQH\ WUHDWHG ZLWK \$03 RQO\ DQV H[HQVRI WKIU  
 NLGQH\ WKDW UHFHLYHG LVFKHPLD RQO\ IRUHOLO DQG PLQXWHV  
 UHVSHFWLYHO\ /DQHV DQG NLGQH\ RI DQLPDOV WKDW ZHUH SUH  
 FRQGLWLRQHG ZLWK \$03 DQG WUHDWHG ZLWK LVFKHPLD IRU DGPLQVWUDWLRQ  
 PLQXWHV UHVSHFWLYHO\

LVFKHPLD UHODOLVFKHPLD ODQH UHODOLVFKHPLD ODQH :H E  
 DQG OHWKRQV IRU WKH VRXUFHV RI  
 WKH DQWLEGRORJXODOR ZSHJRWFKHFWH  
 PDUNHUV JDOHFWLQ 08& /LSRFDOLQ DQG &VWDWLQ & DUH  
 GHSLFWHGHYHOV \$03 DFWLYDWHG NLQDYH \$03 ZD\ DQV FHOO VLJQDOLQJ  
 DQDO\JHG ,Q SDUDOOHO LWV DFWLYDWHG VWDWLQ ZD\ DQV IRORZHG XVLO  
 SKRVSKR DSHWLERG\ )RU QRUPDOL]DWLRQ SURWHLQ ORDGLQJ  
 WKH H[SUHVVLRQ\ODQH ZHOORZHG /DQHVYKDP RSHUDWHG  
 NLGQH\ ODQH NLGQH\ WUHDWHG ZLWK \$03 RQO\ DQV H[HQVRI WKIU  
 NLGQH\ WKDW UHFHLYHG LVFKHPLD RQO\ IRUHOLO DQG PLQXWHV  
 UHVSHFWLYHO\ /DQHV DQG NLGQH\ RI DQLPDOV WKDW ZHUH SUH  
 FRQGLWLRQHG ZLWK \$03 DQG WUHDWHG ZLWK LVFKHPLD IRU DGPLQVWUDWLRQ  
 PLQXWHV UHVSHFWLYHO\



d\$03 PHGLDWHG SUH FRQGLWLRQLQJ S\LRU WR LYXUHFWDXGHH DUSUDZDQHWIRG KH  
WKH IDFW WKDW d \$03 FRXOG IXQFWLRQHQDWLYRQRO UHDSFWLWHLRQ\JZHQLDQDQDQHL  
GLDJUDPPDWLFDQO\ UHSUHVHQWHG LQ LQJXVFKHPLF DQLPDOV SUHWUHDWHG ZLWK  
PHFKDQLVWLF OLQN EHWZHHQ \$03. DFWL  
VWUHV > @



,W LV DOVR NQRZQ WKDW 1UI SOD\ D  
DFXWH NLGQH\ LQMXU\ \$., DQG WKLV S  
HQGRJHQRXV DQWL R\LGDQW SDWKZD\ ZK  
\$03. > @ LQGXFWRQ RI WKH K\SRPHWD  
\$03 PD\ XSUHJXODWH WKH DQWL R\LGDQW  
NLGQH\ WLWVXH WKURXJK WKH DFWLRQ RI  
LQGLFDWH WKH SRVLELOLW\ WKDW WKLV  
FRXOG EH XVHG WR H\WHQG WKH ZDUP LV  
VDPH WLPH UHGXFH WKH UHSUHXVLRQ GI  
LQWHUHVWHG LQ GHYLVLQJ VHYHUDO VWU  
VDPH WLPH SUHVHUYLQJ JOREDO SDUHQF

)LJXUH d \$03 ZRUNV WKURXJK PXGWL  
K\SRPHWDEROLVP FUHDWHG E\ WKLV  
LQGLYLGXDO PHFKDQLVPV DV )KXV  
'LVFXVLRQ VHFWRQ IRU D GHWDLOHG  
EUDQFKHV LQ WKH PHFKDQLVP RI DFWL

)LUVV WKH UDWLRLQ\SDQWEDVHLG ZLWK  
WR DQ LPEDODQFH WR WKH HQHUJ\ VHQV  
ERG\ OHDGLQJ WR D VORZGRZQ UHGFB  
FHOV DYLGO\ WDNH XS WKLV QXFOHRW  
JO\FRO\WLF SDWKZD\ DV WKLV LQROH  
LQWUDFHOXODU \$03 ZLOO IRUFH WKH  
XWLOL\QJ WKH DFCWDCU \$73GSRHQ  
SDWKZD\ > @

OHWDEROLWH FKDUFDWHUL]DWLRQ DQ  
\$03 DGPLQLVWUDWRQ OHDGV WR DQDQ  
ELVSKRVSKRJO\FHUDWHZGLWK KFRU  
R\JHQ > XV@KHQ WKHGH\RLHQW EOR  
FLUFXODWH WKURXJK WKH ERGWLW  
LQWUD WLWVXH K\SR\LD DW WKH OHDV  
LVVJQL\ERQWHDVH LQ WKH OHYHO RI  
,) @6HFRQG LW LV VWLOO WKHRUHW  
GHSKRVSKRU\ODWHG WR DGHQRVLQH  
DGHQRVLQH UHFHSWRUV OHDGLQJ WR  
ERG\ WHPSHUDWXUH %XW DPRQJ WKH  
UROH RI WKH \$03 DFWLYDWHG NLQD  
LPSRUWDQFH 2XU VWXGLHV VWURQJO  
DFWLYDWHG DQG IXQFWLRQDO LQ LQK  
\$&& E\ SKRVSKRU\ODWLRQ

:H SURSRVH WKDW PRMFWH QWIKH W  
EH H[SODLQHG E\ WKH DFWLYDQRLQ  
FKDUDFWHULVWLFDOO\ VKRZEDQ WKH  
SUHFRQGLWLRQLHGSKCLPDDQV RQ  
VWDELOL]DWLRQ FRXOG EH RQH RI WK  
UHQR SURWHFWMMYSH RI K\SR\LF SUH  
VKRZQ WR SURGXFWH UHFRSUOLHFW  
UHVXOWV SUHVHQWHG KHUH SDUDOOHO  
ODERUDWRU\ > @

)RXUWK ZH DQWLRLHFWHWDWLRQ LQ  
DQWL R\LGDQW WUDQVFULSWLRQ IDFW  
LVFDQ EH H[SODLQHG E\ WKH IDFW  
UHVSRQVLYH HQJ\PH EXW DOVR D UH

&LWDWSDQ[ DQGHU % -DPHV 0 )LVKPDQ \$ \*UDVVR 0 'RUDL 7 ,QGXFWLRQ RI +\SRPHW  
5HSHUHXVLRQ ,QMXU\ LQ 5HQDO 5HFRQVWUXFWLRQ GRUJHULHV - 7UDQVSODQW 7HFKQ

3DJH RI

JUDWHIXOO\ DFNQRZORGVHBUH WKDQNXORWRL %KFKYHDOH\ZTRDQIDUE '6 \*UDVVR 0  
'RUDL IRU D EOLQG HG SDWKRRR JLFDQ LQPHU SUYFKHPWR LQ PRIGWKLQJDFXSPHWRWRESL  
QHUFURVLV LQ WKH LPPXQRKDXWRRKMPDOWRHWKODQGHV  
-RKQ 7 3LQWR %LRFKHPLVWU\ DQG ORO RPHO DLFKORR J\ROGSDUEWPHQVVR 0  
1<0& IRU KLV VXJJHVWLRQV DQG IRU D FDU RPHO DLFKORR J\ROGSDUEWPHQVVR 0  
- IHSKURO 8URO

### 5HIHUHQFHV

\*HLVHU ) +LEHUQDWLRQ &XUU %LRO  
6WRU%\ 6WRUH\ -0 0HWDEROLF UDWH GHSUWVLRQ VWRU%  
RI PDPPDOLDQ KLEHUQDWLRQ \$GY &OLQ &KHSDUWLDO QHSKUHUMRPS ZFWKFDWDRKORR  
6WRU%\ RXW FROG ELRFKHPLFDQ UHXODWLRQ RI PDPPDOLDQ  
KLEHUQDWLRQ \$ PLQL UHYLHZ \*HURQRORJ\ %HUQKDWGW :0 &DPSHDQ 9 .DQ\ 6 -XUJHQV  
\$GGUHZV 07 \$GYDQFHV LQ PROHFODU ELRPHFRGKWLWRQDWLWLRQWLRQ RI K\SR  
PDPPDOV %LR (VVD\V LVFKHPLF DFXWH UHQDO IDLOXUH - \$P 6RF 1  
ORULQ 3 -U 6WRUH\ .% ODPDOLDQDWLRQ%HUQKDWLRQJ / &HOOXODU SDWKRSKIV  
H\SUHVVLQR DQG QRYHO DSSOLFDWLRQ RI H\LEOHVWDMFRQWLRQV ,QYHWVHY %LRO  
)HUQKDWGW %HWRFFKL \$3 &DPSDQKROH \* :DQJ  
+HOGPDLHUWDPDQQ 6 (OYHUW 5 1DWXUDORR\SRPHWDEROLVP \$UROH IRU JDOHFV  
GXULQJ KLEHUQDWLRQ DQG GDLO\ WRUSRUWULQJPHRQGLVFKHPLD DQGVLSHUHXVLRQ  
1HXURELRO \$XEHWDTXHHWHW 9 +HPRQ %HSRLYUH 5 %  
+HOGPDLHU \* 3K\VLDERQ\KLEHUQDWLRQ OHLZRFSLD LQGXFLEOH IDFWRU WDUJHW  
FDUFLQRPD WXPUR SURJUHVVLRQ &DQFHU 5  
=KDQJ - .DDVLN . %ODFNEXUQ 05 /HH && 6FKPQWDPQRGLDUNQHV\LODQGGDGH \$ &  
FLUFDGLDQ PHWDEROLF VLJQDO LQ PDPPDOV DFWLRQ RI QHXWURSKLO JHODWLQDWI  
/HH && ,V KXPDQ KLEHUQDWLRQ SRVWHSKURQ \$QQX 5HY 0HG  
6RQJ 6 0H\HU 0 7XUN 75 :LOGH % )HOGND  
%RXPH 9HUKDDJ (0 2WLW -3 +HOGPDLHU \*FZWRDLO &HWQ DORXVH PRGHV D UHOLDE  
,QGXFWLRQ RI WRUSRU PLPLFNLQJ QDWXUDORRPHRQGLVFKHPLD DQGVLSHUHXVLRQ  
ELRPHGLFDQ DSSOLFDWLRQV - &HOO 3K\VLRO  
%HUQKDWGW :0 :DUQHFNH & :LOODP & 7DGDNDORRHWLWVXKHUHG HW \*DORR \$\* 6WRUH  
2UJDQ SURWHFWLRQ E\ K\SR\LD DQG UHSDORRDLQWALFOH VDFWRORJ LQ D QDWX  
0HWKRGV (Q)\PRO UDWH GHSUHVLRQ 0RO &HOO %LRFKHP  
\*XLEHUW3HWUHQR \$< %DODEDQ &/ 6RPRY &DORRGLRPHR -9 \*HWQDORQL (&KLDUXJL 3  
2UJDQ SUHVHUYDWLRQ &XUUHQW FRQVHUYDQWLRQ VWRU%VWRU%VWRU%VWRU%VWRU%VWRU%  
QH[W GHFDGH 7UDQVIXV 0HG +HPRWKHU VRXUFHV RI UHDFWLYH R\JHQ VSHFLHV 3/R  
7ULSDV DDDWHO 16 &ROOLQR 0 \*DOOLFCLR -DUGHMZRVK -)\$HWDDOH\ 6\$ \$03. D QXV  
\*HQHUDWLRQ RI HQGVRXORRPHVWKLRO LQHVWRPDKDW PDLQDWLQV HQUJ\ KRPHV  
0\DVH OLPLWV UHQDO WLVVXH LVFKHPLD UHSHUHVLRQ LQMXU\ DQG G\VIXQFWLRQ /DE  
,QYHVW +DUGLH \$03 DFWLYDWHG SURWHLQ NLQD  
/HH +- 0DULDSSDQ 00 )HOLHUV ' &DYDJOLHUWSDWHDWDDWSDWHDWDR\FHWD IXQFWLR  
DO +VXURRGLHLELWV KLJK JOXFRVH LQGXFLEOH DFWLRQV +RZHOO .%XUQH  
V\QWKHVLV E\ DFWLYDWLQJ \$03 DFWLYDWHG SURWHLQNLQDQDWLRQWLRQ R\SWKHPDORR  
FHOOV - %LRO &KHP IDFWRU 1UI PHGLDWHV F\WRSURWHFWLYH  
%RMO /HXHQQLQN +\* 6QLMGHU 30 .ORRVWHWLVLRODQGWQ \$6(%HW  
DO +OYHDDQGXFHG K\SRPHWDEROLVP +RPHOQXW\DLQDQO\LOZRUK 60 6WRUH\.%  
LVFKHPLD UHSHUHXVLRQ LQMXU\ - \$P 6RF 1H\SKURQ WLRQ RI WKH UROH RI \$03 DFWLY  
/LX <+ /X 0 %LDQ -6 VXO)DGGURJHOD LVFKHPLD UHDP WDUJHW LQ PDPPDOLDQ KLEH  
([SHUW 5HY &OLQ 3KDUPDFRO %LRFKHP 0RO %LRO  
1LFKROVRQ & .&DOYHUW VXO)DGGURJHODX 0 \*ULJRUIHY '1 URZ 07 +DDV 0 <DPD  
UHSHUHXVLRQ LQMXU\ 3KDUPDFRO 5HV 7UDQVVLWLRQ IDFWRU 1UI LV SURWHFW  
=KDR = 0LNL 7 9RQ 2RUW -DQVHQ \$ 0DWVX DFWLYH NLQDQHH '6QMXUDDQ PLFH .LGQH\ ,QW  
+HSDWLF JHQURJHUVSRQVSRQ LQGXFHG K\SRPHWDEROLVP 6/ -DLQ 6 .H\V ' (GHVWHL  
PLFH 3K\VLRO \*HQRPLFV DGDSDWLRQ GXULQJ KLEHUQDWLRQ \$P -  
'DQLHOV ,6 =KDQJ - 2d%ULHQ ,,, :\* 7DR = 0LNL 7 HW DO \$UROH RI  
HU\WKURF\WHV LQ DGHQRVLQK BRERWDEROLVSHLSHWLWLRQORUWLQ - 3DFLF \$ /MXED  
LQ PDPPDOV - %LRO &KHP SURWHFWLRQ IURP SURORQHJH FROG LVFK  
=KDR = 9RQ 2RUW \$ 7DR = 2d%ULHQ ,,, :KLEHHQD\WLRQV LUUHOV 7UDQVSODQDWL  
0HWDEROLVHQ \$03 LQGXFHG K\SRPHWDEROLVP DGGURJHOD RPHOQXW\DLQDQO\LOZRUK  
PHGLDWHG VLJQDO WUDQVVGXFWLRQ EH\RRQ  
0LFKHROVRUDL 7 &KDQGHU 3 &KRXGKXU\ 0 \*UDVVR 0 HW DO  
+\SR\LF SUH FRQGLWLRQLQJ LQ D UDW UHQDORR\FWHPLD RPHO - DQPHYDQXWFRQVWDRWDO  
WKH XVH RI K\GUDOD]LQH :RUOG - 8URO EHWZHHQ 1UI DQG \$03. VLJQDO SDDQV\



&LWDWISQ[DQGHU % -DPHV 0 )LVKPDQ \$ \*UDVVR 0 'RUDL 7 ,QGXFWLRQ RI +\SRPHWD  
5SHUHXVLRQ ,QMXU\ LQ 5HQDO 5HFRQVWUXFWLRQ GRUJHULHV - 7UDQVSODQW 7HFKQ

3DJH RI

LQ~DPPHWRBW EHUEHULQH LQ /36 VWLPXODVGHVDFKRSK/DSDU DQGRSLF SDUWLDO QHSH  
HQGRWR[LQ VKRFNHG PLFH \$QWLR[LG 5HGR[FHQZDODYRLG LVFKHPLF GDPDJ(KURWKH UH  
3RUSL)JSHQDUG - %LOOD 0 0XVVR ) 9ROSH \$ HW DO ,V UHQDO  
ZDUP LVFKHPLD RYHU PLQXWHV GXULQJ ODSMPDGRSLF SDUWLDO DQGRSLF HQGRWRBW \*  
SRVVLEOH" 2QH \HDU UHVXOWV RI D SURVSHWHYHURVXEV (XUHQD IURP D SULPDWH - 8