

%LRORJ\ DQG 0HGLFLQH 'XJJHWW 1\$ HW DO %LRO 0HG  
KWW\$ G[ GRL RUJ

5HVHDFK \$UWLFOH

2SHQ \$F

/RZ ,QWHQVLW\ /LJKW 7KHUDES\ QP 3URW  
IURP \$P\ORLG 0HGLDWHG &HOO 'HDWK

1DWDOLH \$ 'XJJHWW DQG 3DXO / &KD]RW  
6FKRRO RI %LRORJLFDQ %LRPHGLFDQ 6FLHQFHV 'XUKDP 8QLYHUVLW\ 6RXWK 5RDG 'XUKDP '+ / ( 8QL  
&RUUHVSRLGLQ3DXO&KD]RW 6FKRRO RI %LRORJLFDQ %LRPHGLFDQ 6FLHQFHV 'XUKDP 8QLYHUVLW\  
( PD\$OXO FKDJRW#GXUKDP DF XN  
5HFHLYHG-&DWH \$FFHSWHG&DWH 3XEOLVKHG&DWH  
&RSULJKW 'XJJHWW 1\$ HW DO 7KLV LV DQ RSHQ DFFHV DUWLFOH GLVWULEXWHG XQGHU WKH WHUPV R  
XVH GLVWULEXWLRQ DQG UHSURGXFWRQ LQ DQ\ PHGLXP SURYLGHG WKH RULJLQDO DXWKRU DQG VRXU

\$EVWUDFW

8VLQJ D VLP\$DWRRLGRSDWK\ &\$' QHXURQDO PRGHO LQIUDUHG ,5 QP OLJKW  
ZDV LQYHVWLJDWHG DV D QRYHO QHXURSURDWRPHVLSH SWLLGHV ZDV 6XCEWIKHFWLHG KX  
DJJUHJDWLRQ LQ D WHVW WXE DQG VKRZQ WR IRUPPILZUKLFK RRP\$UBQUMHRI VLJH  
WKH FHOXODU QXFOHU LQWHJULW\ RI &\$' FHOOV LQ FXOWRPHVLSH QG HOLFLWHG  
SHSWLGH FRQFHQWUDWX&QVBDQJHZKLFK ZDV VLJQLILFDQW\ VXESUSULVHUG XS WR  
WUHDWPHQW ZLWK ,5

.HIZRUGRWRRELPRGXODWLRQ /RZ ,QWHQVLW\ /LJKW 7KHUDES\ QP 3URW  
,QIUDUHG DP\ORLG 7KH FHOV OLQH H[SUHVHVH QHXURWUDQV  
VSHFLILF SURWHLQV LQFOXGLQJ DFWLY  
V\QDSWRSK\VLQ DOO RI ZKLFK SURYLGH Y  
RI QHXURQDO V\VWHPV LQ YLWUR > @  
\$EEUHYLDWLRQV \$• DP\ORLG \$' \$OJKHLPHUDV GLVHDVH \$73 DGHORVLQH  
WULSKRVSKDWH &\$' &DWK D GLIIHUHQWLDOH GLVHDVH LQGLVWULEXWHG WKH FHOV  
V\QWKDVH ,5 LQIUDUHG ,5 LQIUDUHG SURJUHVV\YH GHODWLRQ FKDBDFWLRQ  
GHK\GURJHQDVH /,/ /RZ ,QWHQVLW\ \$LJKW 7KHUDES\ 33 HIWUDFHOOXODU VW  
PHWKO\ SKHQ\OS\ULGLXP 1,5 QHDU 63V ZKLFK DUH WKBRXJKW WR LQGXFH V  
89\$ XOWUD YLROHW \$ VWDELOLW\ RI WKH FHOV PHPEUDQH V  
WUDQVPLVLRQ > @ DQG LPSDLULQJ V\Q  
UHSRUW KDYH VROLHWHVWIDWKS HU WKD  
DUH WKH PRUH WR\LF VWUXFWXUH DQG V  
,QWURGXFWRQ EHHQZHHQSDWK\WR RPSRFXUH DQG QHX  
,QIUDUHG UDGLDWLRQ QP KDV EHHQZHHQSDWK\WR RPSRFXUH DQG QHX  
XS WR RI WKH VRODU UDGLDWLRQ ZKLFK EHHQZHHQSDWK\WR RPSRFXUH DQG QHX  
1HDU ,QIUDUHG 1,5 OLJKW W\SLFDOO QHXURQDO D\DELOLW\ P ZKWK ERPHU  
VKRZQ WR KDYH D ZLGH UDQJH RI ELRORJ\ DFWLYHWV ZKLFK DFWLYH X  
EHQHILWV DQG D JUHDW GHDO RI UHVHDUFK KDV EHHQZHHQSDWK\WR RPSRFXUH DQG QHX  
WKH RSWLPDO SDUDPHWHUV ZKHWKHU G\KHD EHHQZHHQSDWK\WR RPSRFXUH DQG QHX  
RU OLJKW VRXUFH /DVHU RU /('V > RRG\ZOWH\Y\W\Q\HG\K\WR\7R\H\B\H\H\VD\VKW  
/,/ DOVR NQRZQ DV SKRWRELPRGXODWLRQ DFWLYHWV WKH RSWLPDO FWR VLWX  
PRGXODWH D FRQVLGHUDEOH QXPEHU VRI EKKR PRGHO ZDURPHVLSH QG DFWLYH  
VLJQLILFDQW QXPEHU RI VWXGLHV 7KHUHQHQDQGZKLFKHUHU LLUDZRRWRGRRZDQK  
UDWHV > @ LQGXFWLRQ RI FHOXODU WRSURF\IHUDWLRQ LQ PXOWLSOH FHOV FX  
V\VWHPV LQFOXGLQJ RVWHREODVV > 7KH WUREODVV @PXVFOH' FHOV  
DQG HSLWKHOLD FHOV > @ +HLSHFXHQD\WKH\K\DW\Q\W\LFH\Q\W\UDWLRQ R  
ODELWDFWLRQV > @ LQFUHDVLQJ \$73V UHVHDVHV DQ SHDN LQ WUDQVPLVLRQ  
UHVSLUDWLRQ UDWHV > @ WKUHIRUH UHTXLUHV OHVV HGHU\ WR  
/,/ KDV DOVR EHHQ VKRZQ WR SURFHHQ WKH WUHDWPHQW DQG SURFHHQ EXW  
DJDLQV D QXP\HUVLW\ DFWLYHWV89\$ > @H\SRQD\VVLRQ P  
FIDQLGH > @ PHWKDQRO GHULPHV KRWSDWK\WR RPSRFXUH DQG QHX  
SKHQ\OS\ULGLXP DQG URWHQRQH > @ SURFHHQ FHOV DFWLYHWV RPSRFXUH DQG QHX  
XQLTXH PHWKRQ WR VWXG\ HYHU\ IDFHW RI QHXURQDO SURFHHQ FHOV DFWLYHWV \$ LO  
UHSURGXFLELOLW\ LQ DOEHLW D VLP\$OLILHG V\VWHP 7KH &\$' &DWK D  
GLIIHUHQWLDOH FHOV OLQH DUH FDWHFKRODPLQHUJLF FHOV GHULYHG IURP  
&DWK D FHOV OLQH ZKLFK ZDV SURFXUH IURP D EUDLQ WXPRU WKDW KDG  
GHYHORSHG LQ D WUDQVJHQLF PRXVH PRGHO &\$' FHOOV VSRQWDQHRXVO\ ORVW

0DWHULDOV DQG 0HWKRGV ([SHULPHQWDO 6HW 8S

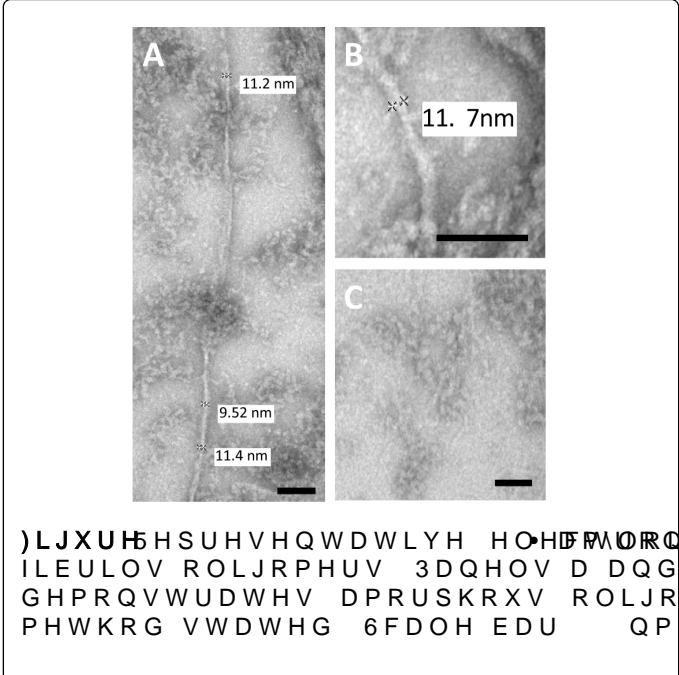
&HOO PDLQWHQDQFH &\$'V DQG \$•

&\$' &DWK D a GLIIHUHQWLDWHG &HOOV KZKHUV PDVWHUDEHQGLQHUHFSDVVHGL '0(0) \*OXWDQG IRHWDO FDOI VHWXSRVHG WLR ILYHPVHVW RI PLQXWH ,5 IODVNV XQWLO UHDFKLQJ FRQIOXHFFLQXWHVFBDVWPPDQ\$WFMOQV ZHWLQWHW XU WKH\ ZHUH SDVVVDJHG LQWR ZHOO SODVHW WLPHO SHUGZHOZDV UHPRYHG DQG \*OXWD0\$; )&6 FRQWDLQLQJ WKH GHVLUH

3UHSUDWLRQ RI • DP\ORLG ILEULOVP\ORLGSHSWLGHXHPHQDOWHODVXWHV F +XPDQDP\ORLGSWSWLGH ZDV SXUFKDVWKR LQFXEDWLRQ KRXUVFDOVHLOWKHFDG 6FLHQWLILF 8. XSRQ DUULYDO SHSWLGHZHUZDYDQGVRSVHG WR ILYH WRWV RI P PJ PO DQG VWRXQGVXVH 3ULRU WRDQGHJWKHSHWUHQGWR WKH LQFXEDWLGLOXWHG WR wo XVLQJ VWHULOH 3%6 7KH SHSWLGHZPXUWHD &LWR7R IRU KRXUV DW ZLWKRXW DJLWDWLRQ SZKHRSWSWLGHWRM WKHOV GLOXWHG WR WKH UHTXLUHG FRQFHQWUDWLRQ XVLQJ '0(0) SOXV \*OXWD0\$;p )&6 LQYHUWHG DQG JHQWOPDQGGHGWRGHXURFQGH ZLWKJL FXOWXUHV &RQWURO FXOWXUHV ZHUH 'FRQGXFWHG XVLQJ WKH VDPH '062 3%6 UDWLR DV IRU \$• FRQGLWLRQV LQ '0(0) &\$SFXHOOXZHUHSDVVHG LQWR ZHOO FRYHU VOLSSHG DQG FRDWHG ZLWK SRO\ C KRXUVLQ '0(0) \*OXWD0\$;IWHU WKLV

(OHFWURQ PLFURVFRS\ (OHFWURQ PLFURJUDSKV ZHUH REWDLQHG RULJXUDP HSRXUWHZLWK WKH QXWH VWUXFWXUHDP\ORLGSWSWLGH IROORZLROORZLQWRHFDVWPHQW FXOW GHVFULEHG DERYH \$• DDPHGR I SHSWLGHZPXUW IWHU WKLV WLPH WKH LPDJHG SULRU WR WKH XVH RI WKH SHSWLGHZPXUWV%6DPS%6 ZHUH QHJDWLYH VWDLQHG ZLWK XUDLQDPHWDVWHQGLFKLQHQGVZWHU IRLK PHVK IRUPYDU FRDWHG FRSSHU JULQXWV DQG WKHQ ZDVKHG ZLPH DV YLHZHG XVLQJ D +LWDFKL + 7UDQVPLWLRQ (OHFWURQWHXURFQGH 'UULWRQ &KULVWLQH 5LFKDUGVRQ FRQGXFWHG DQOZDVKHGWRGHPRURVSA LQ%6\$)UD +LVWRORJ\ ODERUDWRU\ ZLWKLQ WKH SHSWLGHZPXUW%6DPS%6)UD O'RSLQJH SRZGHUKDP ,FRQZDWHU II ZDV XVHG WR EORFN WKH FHOOV IRU DQWLERG\ ZDV GLOXWHG LQ 3%\* DQW SULPDU\ DQWLERG\ IRU RQH KRXU DW URR ZDVKHG WKUHH WLPHV XVLQJ 3%6 7 DQ VHFRRGDU\ DQWLERGLHV DQWL SKHQ\OLQGGROH DQWL UDEELW \$OH )ROORZLQJ ILYH ZDVKHV ZLWK 3%6 7 FRYH VOLGHV ZLWK ORZLRO &DOELRFKHP 8. D URRP WHPSHUDWXUH LQ WKH &HOOVH LQVSHFWHG XVLQJ D &DUO =HLVV \$LRV HSLIOXRUHVVFHQFH ,PDJHV ZHUH FDSWXUH &&' FDPHUD FRQWUROOHG E\ ,PSURYLVLRQ

(OHFWURQ PLFURVFRS\ (OHFWURQ PLFURJUDSKV ZHUH REWDLQHG RULJXUDP HSRXUWHZLWK WKH QXWH VWUXFWXUHDP\ORLGSWSWLGH IROORZLROORZLQWRHFDVWPHQW FXOW GHVFULEHG DERYH \$• DDPHGR I SHSWLGHZPXUW IWHU WKLV WLPH WKH LPDJHG SULRU WR WKH XVH RI WKH SHSWLGHZPXUWV%6DPS%6 ZHUH QHJDWLYH VWDLQHG ZLWK XUDLQDPHWDVWHQGLFKLQHQGVZWHU IRLK PHVK IRUPYDU FRDWHG FRSSHU JULQXWV DQG WKHQ ZDVKHG ZLPH DV YLHZHG XVLQJ D +LWDFKL + 7UDQVPLWLRQ (OHFWURQWHXURFQGH 'UULWRQ &KULVWLQH 5LFKDUGVRQ FRQGXFWHG DQOZDVKHGWRGHPRURVSA LQ%6\$)UD +LVWRORJ\ ODERUDWRU\ ZLWKLQ WKH SHSWLGHZPXUW%6DPS%6)UD O'RSLQJH SRZGHUKDP ,FRQZDWHU II ZDV XVHG WR EORFN WKH FHOOV IRU DQWLERG\ ZDV GLOXWHG LQ 3%\* DQW SULPDU\ DQWLERG\ IRU RQH KRXU DW URR ZDVKHG WKUHH WLPHV XVLQJ 3%6 7 DQ VHFRRGDU\ DQWLERGLHV DQWL SKHQ\OLQGGROH DQWL UDEELW \$OH )ROORZLQJ ILYH ZDVKHV ZLWK 3%6 7 FRYH VOLGHV ZLWK ORZLRO &DOELRFKHP 8. D URRP WHPSHUDWXUH LQ WKH &HOOVH LQVSHFWHG XVLQJ D &DUO =HLVV \$LRV HSLIOXRUHVVFHQFH ,PDJHV ZHUH FDSWXUH &&' FDPHUD FRQWUROOHG E\ ,PSURYLVLRQ



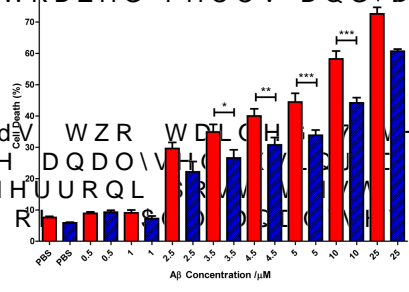
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&\WR7R[ QRQ UDGLRDFWLYH DVVD\ &\WR7R[ DVVD\ NLW TXDQWLILHV /'+ O DV D PHDVXUH RI FHOO O\VLV QHFURVLV FHQWULIXJHG DW USP IRU WZR P FRQWDLQLQJ WKH /'+ ZDV UHWDLQHG DQG XVLQJ WKH VDPH YROXPH UHPRYHG IURP V LDFURZHUOKRIWKH ZHOO SODVHV 7KH EWRZKHIXDPSOV RI&LWRLOVHZKHODPDLQ PHWK5ZMWUXGDXUHQWURXVHG EWWKH USP VXSHUQDWDQW ZDV UHWDLQHG DV D PHDV DQG ZHUH PDGH RI HDFK VXSHUQDWDQ '0(0) SOXV )&6 WR FDOLEUDWH WKH D GLOXWLRQV ZHUH DOO FOPSOHWKGLQDWHV DGGHGWRRI HDFK GLOXWLRQ SULRU WR L URRP WHPSHUDWXUH LQ WKH &DVMR)RO

ZDV DGGHG WR HDFK GLOXWLRQ DQG WKH DEVRUEDQFH PHDVXUHG DW QR RQ D 0XOOLNDQ \$VFHQW 3ODWH 5HDGHU 9HUVLRQ /'+ UHOHDVH ZDV QRUPDOL]HG DJDLQVW WKH VXP RI WRWDO /'+ DEVRUEDQFH FRPELQLQJ WKH DEVRUEDQFH RI SRVLWLYH FRQWURO IUHH]H WKDZHG FHOOV DQG DEVRUEDQFH RQLQLWLDO PHGLD FRQWDLQLQJ /'+ UHGGLQJV

6WDWLVLV

'DWD ZHUH DQDO\HG XVLQJ D 6WXGHQWV LPPXQRIORUHVHQFH DQDO\VLV 'DWD ZHUH DQDO\VLV 'DWD ZHUH \$129\$ DQDO\VLV RI YDULDQFH XVLQJ D %RQHURQL PHDQ s 6(0 ZLWK D FRQLGHQFH LQWHUYDO RI FRQGXFWHG XVLQJ \*UDSK3DG 3ULVP 9HUVLRQ



/' \$UUD\

QP HPLWWLQJ /(' DUUD\ KDYH D QP SXOVHG DW +] ZLWK D GXW P: FP 6KDP WUHDWPHQWV ZHUH FRQGXLW ZLWK DOXPLQLXP IRLO SODFHG RYHU 9LUXOLWH 'LVWULEXWLRQ /WG 8. DQG 'RXJDO 9LUXOLWH 'LVWULEXWLRQ /WG 'HSDUWPHQW 'U \$QGUH %HHE\

5HVXOWV

\$P\ORLG DSSHDUDQFH

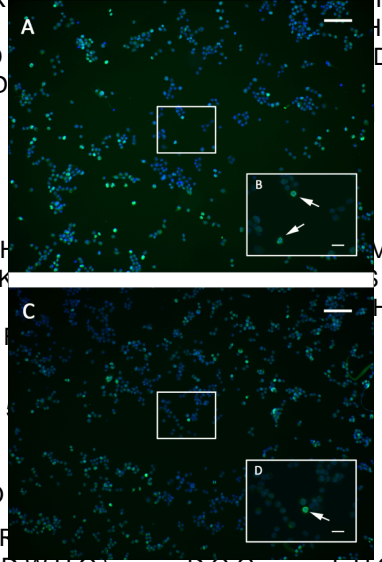
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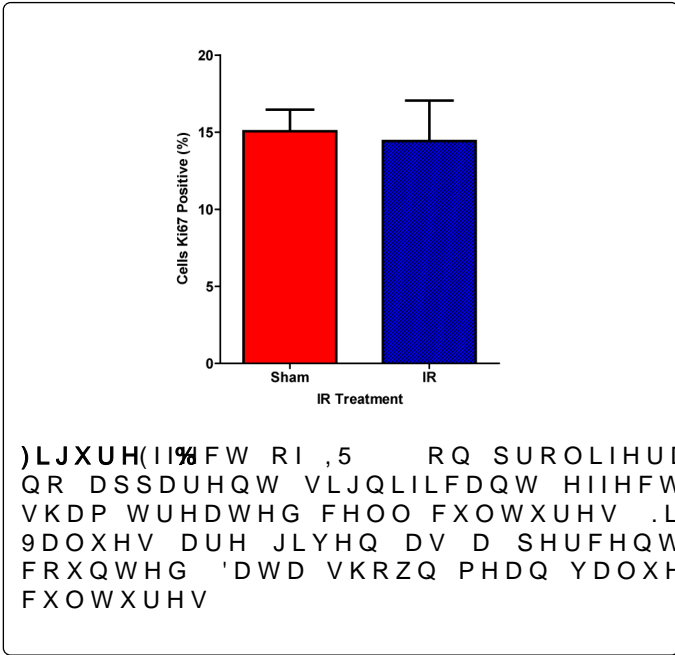
&\$' &HOOV \$• LQGXFHG WR[LFLW\ DQG ,5

([SRVXUH WR ,5 KDG QR VLJQLILFDQW WUHDWHG FRQWUROV DJDLQVW FHOV GHDWK ZKRUH +RZHYHU WKHUH ZDV D WUHQG IRU GHDWK LQ WKH ,5 WUHDWHG FRQGLWLRQ FRQWUROV QDW -0 \$•

\$W -0 \$ WUHDWPHQW RI &\$' FHOOV ZLWK VWDWLVLVFDQO\ VLJQLILFDQW UHGXFHG ZDV LQFUHDVHG DW S DQG S FRPSDUHG WR VKDP WUHDWHG FRQWURO

&RQFHQWUDWLRQV ZHUH H[FHHGLQJO\ WR WR 6KDP WUHDWHG FHOOV FDXVLQJ DSSUR[LPDWHO\ UHVSHFWLYHO\ +RZHYHU GHVSLWH WUHDWPHQWV FHOOV ZLWK ,5 VLJQLILFDQWO\ UHGXFHG UHVSHFWLYHO\ QERWK FRQFHQWUDWLRQV WKH ZKLWH ER[ LQ ILJXUH \$ DUURZV ,5 7UHDWHG &\$' FHOOV ' 0DJQLHG LPD WKH ZKLWH ER[ LQ ILJXUH & -LJXUHV % ' VFDOPEDUURZV LQGLFDWH .L SR FHOOV





ILJXUH(11% FW RI ,5 RQ SUROLIHU...  
QR DSSDUHQW VLJQLILFDQW HIIHFV  
VKDP WUHDWHG FHOO FXOWXUHV .L  
9DOXH V DUH JLYHQ DV D SHUFHQW  
FRXQWHG 'DWD VKRZQ PHDQ YDOXH  
FXOWXUHV

'LVFXVVLRQ

7KHUH DUH D VLJQLILFDQW QXPEHU  
IRUP. \$ODTXHV IURP. V...  
cJURZL...  
WLJKWO\ FRQWUROOHG DQG PDQLSXOD  
PL[WXUH RI VWUXFWXUHV +RZHYHU  
WKH IRUPD...  
DELOLW\ RI VWUXFWXUHV IRUPHG LQ  
VLJQLILFDQWO\ GLIIHUHQW HILFDLHV  
VWUWLQJ SHSWLGH > @ \$ QXPEHU  
FUHDWLRQ. RI...  
UDQJH RI SHUPXWDWLRQV H[DFWHG  
ILEULOV RU ROLJRPHUV > @ \$ Q  
DQ \$Q]KHLPHUDV GLVHDVH PRGHO V  
VLPSOH PHWKRG WKURXJK ZLJKV  
EH IRUPHG ZKLFK SHUKDSV PRUH FOR  
FOLQLFDOO\ SUHVHFW LQ WKH \$Q]KHL  
WHFKQLTXHV SXEOLVKHG > @  
PHWKRG GHVFULHG KHUHLQ ZHUH DS  
GLIIXVH ROLJRPHULF W\SH VWUXFWXU  
FRQFHQWUDWLRQV VROXWLRQV ILEULOV  
VWUXFWXUHV ZLWK LQGLYLGXDO ILEUL  
DSSHDULQJ WR EH MRLQLQJ RU OHDO  
ROLJRPHUV ZHUH REVHUYDEOH WKUR  
FRQFHQWUDWLRQV DURXQG EUDQFKHV  
ILJXUH WKH VDPH UDQJH DV GLDPH

FRQFHQWUDWLRQV LQ YLWUR LV D QHFH  
V\QWK...  
FHOO GHULYHG \$ \* > @ +RZHYHU  
FRQFHQWUDWLRQV UHDFSK PLFURPRODU  
FRPSDUWPHQWV VR FRQFHQWUDWLRQV  
UHOHYDQFH > @

1,7 DW YDULRXV ZDYHOHQJWKV KDV EHH  
SUROLIHU...  
cRSWLFDQ ZLQGRZ RI 1,5 ZLWK OLWOO  
RU PDMRU WLWVXH FKURPRSKRUHV VXFK  
UHTXLUH OHVV HGHUJ WR SHQHWUDWH E  
ULVN RI WKHUPDO VWUHVV DQG WLWVXH  
SURYLGHG SUHOLPLQDU\ HYLGHQFH WKDW  
SUROLIHU...  
XQOLNHO\ WR EH WKH FDXVH RI WKH DSS  
...  
LQVXOW > @ DQG LPSURYHG KHDOLQJ WL  
LQHFWLRQV > @ 7KH PHFKDQLVP WKUR  
EIHRJLFDQ HIIHFV UHPDLQV XQFOHDU  
XSUHJXODWH L126 LQGXFLEOH QLVULF  
...  
UDQJH RI SHUPXWDWLRQV H[DFWHG  
ILEULOV RU ROLJRPHUV > @ \$ Q  
DQ \$Q]KHLPHUDV GLVHDVH PRGHO V  
VLPSOH PHWKRG WKURXJK ZLJKV  
EH IRUPHG ZKLFK SHUKDSV PRUH FOR  
FOLQLFDOO\ SUHVHFW LQ WKH \$Q]KHL  
WHFKQLTXHV SXEOLVKHG > @  
PHWKRG GHVFULHG KHUHLQ ZHUH DS  
GLIIXVH ROLJRPHULF W\SH VWUXFWXU  
FRQFHQWUDWLRQV VROXWLRQV ILEULOV  
VWUXFWXUHV ZLWK LQGLYLGXDO ILEUL  
DSSHDULQJ WR EH MRLQLQJ RU OHDO  
ROLJRPHUV ZHUH REVHUYDEOH WKUR  
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RI H[SRVXUHV LQ D QHXURQDO FHOQ OLQHQLQXWQH \$UHRMHQ FH<RPRRKH D]JXHRI D V  
EHOLHYHG WR EH D SULQFLSDO FRQWULHFWHU QDRVHU QHUIHQH DWVRQLSWHPRWHYKYV  
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SDWKRJHQLF •HDIGW SURWHLFWLYH DWWULEXWHY KODZ RP L WV 5/LQ%XF KPDQ -5 :KHOD (9  
QHXURQDO FHOQ OLQH (IIFW' RI 1\$ \$ OLJKW HPLWWLQJ GLR  
KHDOLQJ - &OLQ /DVHU 0HG 6XUJ

7KH XVH RI ,5 DV D WUHDWPHQW IRU 6RPHBLPHUQMLGRVSHDVHV WUXQS GHUDQN  
LQYHVWLDWLRQ ZLWK UHFUXLWPHQW RI \$LRWWHQXVDWLRUWZDQGRZ LQOHPRZELQW  
GRXEOH EOLQG SODFHER FRQWUROOHG #DQQ#DO DQLD06\$ VKLJUVHVPWWRWLRQ  
WULDOV ZLOO HQDEOH VWDWLWLFDOO\ YHQLGXFRQFOXVLRQV WR EH GUDZQ UH  
WKH XVH RI ,5 DV D WUHDWPHQW IRU 6RPHBLPHUQMLGRVSHDVHV WUXQS GHUDQN  
FOLQLFDO VHWLQJ 3UHOLPLQDU\ UHVVXWV QRDUWRZV ZDYHEDQOLJKW &OLQ  
GHPRQVUDWH SURWHFWLYH HIIHFW IRU 3DVVDUHQDRDYLVLPJOLRFDQDULZRUP  
UHPDLQV WR EH FRQGXFWHG E\ WKH QHXURQLQV FRQVUDWLRQ SURWHLFW WQHFW  
FRPSOH[ QDWXUH RI \$O]KHLPHUDV GLVHDVH ODVFXUD%8THWW-Q YLWUR

### \$FNQRZOHGJHPPHWW

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VXSSRUWHG E\ WKH %%65& 8. DQG 'XUKDP 8QLYHUVLW\ HP%3RWRVLFDO  
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SUHSDUDWLRQ RI WKH PDQXVFULSW RU GHFLVLQRZYRYSOEDLWK WKHUDS\ DFWLYDWH  
R\JHQ VSHFLHV LQ PRXVH HPEU\ RQLF ILEUR  
ORFKL]XNL .DWDRND < &XL < <DPGD + +H  
(IIFWV RI QHDU LQIUH UHG ODVHU LUUDGLD

### 5HIHUHQFH

)UDQN 6 2OLYHU / /HEUHWURQ '( &RVWHUHQHQRVDM GSKRVSQDWH FRQWUROV RI U  
,QIUHUHG UDGLDWLRQ DIIHFWV WKH PLWRFKRQGULDO SDWKZD\ RI DRSRWVVL LQ  
KXPQ ILEUREODVV - ,QYHVW 'HUPDWRU %UDGRUDUORZ \$ &KD]RW 3/ 3URELQJ  
7VXL &KHQ -& :DQ :- 1HDU ,QIUHUHG \$EVWUOH QOOLJKWHV VWXUFHV ,5 DQG ,5  
RI %LRORJLFDO 6RIW 7LVVXH &RQWLWXHQWYLGRVHQRDRI R\HONHGMLDQ FQGRS UROV UFLWRQ  
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OHVVHUSLU\ 7 6]HQGH %IIFRWRI\*ODVHU UD\ FRLQXHQGXFHG DRSRWVVL 1HXURVFLHQ  
KHDOLQJ \$P - 6XUJ (HOOV+HQU\ 00 6XPPHUIHOW 3 :RQJ 5LOH\ 0  
&KXQ 3HSORZ 39 %D[WHU \*' /DVHU SKRWRPRGXODWLRQW WLF SKRWRPRGX  
ZRXQG KHDOLQJ LQ GLDEHWLF DQG QRQ GLDHEHWDPLWRLFHFWV WURV 1BWCQWFDG 656 8  
XQVSOLQWHG ZRXQV 3KRWRPHG /DVHU 6XUJ :KHOD +7 (HOV -7 :RQJ 5LOH\ 07  
ODUFLSKRQHGUDGR \$3 6LOYD 70 )UDFVVLQJJKWQLKWHWVWLQJ GLRG WUHDW  
,QIOXHQFH RI ODVHU ODPEGD QP DQG GHDPWVQDVSKHQSWLHFLQLXP LRQ  
FKURQROR] RI FXWDQHRXV UHSDLU 3KRWRPRGXODWLRQW WLF  
6DQWRV RV 6DQWRV -1 6REULQKR -% 5DPDWR<0: DQG DUVBQRQLD 0 &KLNDUDLVKL '  
HW DO (IIFWV RI ODVHU SKRWRPRGXODWLRQW WLF PRQBQK \$XV LRZKFK PRUS  
WUHDWHG ZLWK PLWRP\FLQ & D KLWPRPRUSKRPHWLFDGGLXWROHSUFLDOWLRQGL- 1H XU  
D URGHQW PRGH 3KRWRPHG /DVHU 6XUJ 6FKRQHGHUHV - 7KH L SURWHLQ I  
8HG 6KLPL]X 1 (IIFWV RI SXOVH IHTYHQFR- ORLOHAKHOLB DVHU  
WKHUDS\ ///7 RQ ERQH QRGXOH IRUPDWLRQ RLUHQWVDFDULBOLFKOEV6HDQLRN \*  
/DVHU 0HG 6XUJ \$33 SURFHVVLQJ DQG V\QDSWLF IXQFWL  
3LUDOLYHLUD '\$ 'H 2OLYHLUD 5) =DQJDUKSDQNRDLUV0KXWD 7+ \*DUFLD 0XQR] \$ DQ  
(YDOXDWLRQ RI ORZ OHYHO ODVHU WKHUDS\DRI RVWHRU RORLE EHOVD SURWRPQGGDRVHU  
6XUJ \$O]KHLPHU V EUDLQV LPSDLU V\QDSWLF SOD  
.UHLVOHU 0 &KULVWRIHV \$% :LOOHUVKDXVHQ % '+RHG % (IIFWV RI  
ORZ OHYHO \*D\$OV ODVHU LUUDGLDWLRQ RQHWRKSURDQIHUHWLWRBWHW %RI KXPQH W  
SHULRGRQWDO OLJDPHQW ILEUREODVV DQDQKLNHWUR WGXGHDVH OIQ 3HUSRGRQWRQH

&LWDWHDQDOLH \$ 'XJJHWW DQG 3DXO / &KD]RW /RZ ,QWHQVLW\ /LJKW 7KHUHS\ \$P\ORLG 0HGLDWHG &HOO 'HOK %LRO 0HG 6

3DJH RI

6RQGSW 'KDZDQ \* &RPEV & %HWD DP\ORLG DQDOLH \$ 'XJJHWW DQG 3DXO / &KD]RW /RZ ,QWHQVLW\ /LJKW 7KHUHS\ \$P\ORLG 0HGLDWHG &HOO 'HOK %LRO 0HG 6  
ILEULOV VWLPXODWH GLIIHUHQWLDO DFWLYDWLRQ RI SULPDU\ PLFURJOLD 6HH  
FRPPHQW LQ 3XE0HG &RPPRQV EHORZ - 1HXURORJLFDO DFWLYDWLRQ \* %RQQLDXG 3 \*DUUL  
+DUWOH\ '0 :DOVK '0 <H &3 'LHKO 7 DQG SURWHLQV FHOXODU SURWHLQRQ WKURXJK SU  
3URWILEULOV DFWLYDWLRQ RI DP\ORLG EHVWURWHG EORZ GFLHQDVLXWHRUOG-RXUQDO  
HOHFWURSK\VLRRORJLFDO FKDQJHV DQG SURWHLQV LYLH QXURWBLFLW\ GQDFRUVWLFOR  
QHXURQV - 1HXURVFL WKH UHJXODWLRQ RI DSRSWRVLV 6HH FRPP  
.D\HG +HDG ( 7KRPSVRQ -/ 0F,QWLUH 70 &HOOVDF 6 & HW DO  
&RPPRQ VWUXFWXUH RI VROXEHO DP\ORLG RI QXURWBLFLW\ DSRSWRVLV QLYDO IXQFV  
PHFKDQLVP RI SDWKRJHQHVLV 6FLHQFH WKH DSRSWRVLV DQG VWUHV LQGXFLEOH  
.UDQHGX %URXP \*HQWUVPDQDGHG HW DFRPPHQW LQ 3XE0HG &RPPRQV EHORZ - &OLQ  
%HWD DFWLYDWLRQ XVHV GHWDFKPHQW <HQD\ /LX - =KHQJ = 9H[OHU =6 /HH -( HW  
QHXUREOH FHOXODU DFWLQJ DV D VFDIIR GGLDQW EHQDQDPPRQV DFWLYDWLRQ PHFKDQLVPV RI KH  
SODVPLQRJHQ DFWLYDWLRQ 0RO &HOO 1HXURVFLQW LQ 3XE0HG &RPPRQV EHORZ \$QQ 1  
/RUHQ]R DQNHU %\$ %HWD DP\ORLG QXURWBLFLW\ DFWLYDWLRQ UHVIKLND < 0L]RURNL  
IRUPDWLRQ DQG LV LQKLELWHG E\ FRQR %HQFXODU FRDSWLRQ PHGLDWHG WDX SUR  
&RPPRQV EHORZ 3URF 1DWO \$FDG 6FL 8 6 \$ IRUPDWLRQ RI JUDXODU WDX ROLJRPHUV L  
,VREH<DQD]LVZD . 0LFLKNDZD 0 \$ SXEDEGH&RBRQVREHQRZ 0HXURVFL 5HV  
SODTXHV XVLQJ V\QWKHWLF DP\ORLG EHWDO SURWBLFLW\ DFWLYDWLRQ JOLDORXODWLRQ 6HH  
FRPPHQW LQ 3XE0HG &RPPRQV EHORZ ([S 1HXURVFLQW FKDSHURQHV 6HH FRPPHQW LQ  
.XGYD& +LGLQJD +- %XWOHU 3& 0XVNH 5HV 1&RUDBG 1/  
6PDOO KHDW VKRFN SURWHLQV LQKLELW LQ 5HV 0DQVWUHV DQDOLH SURWHLQV KHW DO  
6HH FRPPHQW LQ 3XE0HG &RPPRQV EHORZ )(%6 /HW\ XODWLRQLRPHVSEHQDQV IXQFW  
.LQJ 0 1DIDU ) &ODUNH - 0HDURZ . SURWHLQV DFWLYDWLRQ DQDOLH DQW R[LGDWLY  
SURWHLQ +VS SURWHLQV FRUWLFDO QHXURVSKRQQDWWLRQ WR%LR 01&HWV RI EHW  
DP\ORLG SHSWLGH 6HH FRPPHQW LQ 3XE0HG &RPPRQV (HQD] -1HXURVFL &VHUPHO\ 3  
5HV SURWHLQV DV HPHUJLQJ WKHDSHWLF WD  
(0 \$JQDI 20 1DJDOD 6 3DWHO %3 \$XVWHORVORQV EHORZ %BULODDUDFRO  
ROLJRPHULF VSHFLHV RI WKH DP\ORLG \$ULF SHSWLQV HPHUJLQV DFWLYDWLRQ DQDOLH SURWHLQV  
%ULWLK GHPHQWLD DUH PRUH SRWHQW DFWLYDWLRQ DQDOLH SURWHLQV DFWLYDWLRQ DQDOLH SURWHLQV  
SURWILEULOV RU PDWXUH ILEULOV 6HH FRPPHQW LQ 3XE0HG &RPPRQV EHQD] 7  
- 0RO %LRO PROFXODU FKDSHURQHV DQG WKH KHDW V  
+X ; &ULFN 6/ %X \* )ULHGHQ & 3DSSX 59 HW DO D PLQ\$PVRQV HPHUJLQV FRPPHQW LQ  
IRUPHG E\ FHOXODU XSWDNH FRQFHQWUDWLRQV DQDOLH SURWHLQV RI WKH  
DP\ORLG EHW SHSWLGH 6HH FRPPHQW LQ 3XE0HG &RPPRQV (HQD] 3URF +VS DQG  
1DWO \$FDG 6FL 8 6 \$ QHUVRV V\WHP GLVHDVHV 6HH FRPPHQW  
0LFKDOLHRYDQDFHXU \$ YDQ 5HQVEXUJ 5 %&RPPRQV 5HV ,QW  
(PRWLRQD UHVSQVHV DQG PHPRU\ SHUIRUPDQFH RI PHPRQV DJHG \$LQJ DQG PROHF  
PLFH LQ D 'PDJ HIIHFW RI ORZ LQIUDUH FRPPHQW LQ 3XE0HG &RPPRQV EHORZ ([S \*HU  
&RPPRQV EHORZ 1HXURELRO /HQU 0HP .DUX 3DWEUDW / DOHQGR \* ,UDG  
\*ULOR 'XJJHWW 1\$ (QDFHXU \$ &KD]RW 3DQW 3DWEUDW / DOHQGR \* ,UDG  
LQIUDUH WKHUSD\ QP UHGXFHV \*DQDOLH SURWHLQV 3URWHLQV 3URWHLQV %  
EUDLQ RI DQ \$QKHLPHU V GLVHDVH PRXVH EHQD] \$6730 6HH FRPPHQW LQ  
3XE0HG &RPPRQV EHORZ - 3KRWRFKP 3KRWRFKP 3KRWRFKP (HQD] (RQ]LPD ) 1H  
5, VVLJ)LFKWOVFKHUHU % UHLVDFKRSI . DQDOLH SURWHLQV 6HH FRPPHQW LQ 3XE0HG &RPP  
1LWULF R[LGH LQKLELWV FVSDVH E\ 6QLWURVDWLRQ LQ YLYR 6HH  
FRPPHQW LQ 3XE0HG &RPPRQV EHORZ - %LRO &KHP  
0DUURW%HOD±GL -3 /HMHXQH ) 0HXQLHU -5 \$VWHQDQV HW DO  
3KRWRVWDELOLW\ RI VXQVUHQQ SURGXFWV HIIHFWLQV FLWRFKRQDULDO DQG FHOYLD  
SURWHLQRQ ZLWK UHJDUG WR 89 LQGXFHG PHPRQV 3KRWRFKP SURWHLQV EHORZ %&  
HQGSRLQWV 6HH FRPPHQW LQ 3XE0HG &RPPRQV EHORZ %U - HUPDWRO

.LP <0 7DODQLDQ 59 %LOOLDU 75 1LWULF R[LGH LQKLELWV FVSDVH DFWLYDWLRQ RI QXURWBLFLW\ DSRSWRVLV QLYDO IXQFV  
E\ SUHYHQWLQJ LQFUHDVHV LQ FVSDVH LQKLELWV DFWLYDWLRQ RI QXURWBLFLW\ DSRSWRVLV QLYDO IXQFV  
PHFKDQLVPV 6HH FRPPHQW LQ 3XE0HG &RPPRQV EHORZ - %LRO &KHP

=KRX 3 4LDQ / ,DGHFROD & 1LWULF R[LGH LQKLELWV FVSDVH DFWLYDWLRQ RI QXURWBLFLW\ DSRSWRVLV QLYDO IXQFV  
DQG DSRSWRVLV PRUSKRORJ\ EXW GRHV QRW UHVFH QHXURQDO GHDWK 6HH

7KLV DUWLFQDZ RULJLQDO\ SXEOLVKHG LQ D VSHFLDO LVVXH HQWLWOHG  
7UHDWPHQW 6WUDWHJLHV IRU 1HXURORJLFDO DQG 1HXURGHJHQHUDWLYH 'LVHDVHV  
(GLWHG E\ 6LPRQ .DMD 8QLYHUVLW\ RI 0LVVRXUL 86\$